ORDOVICIAN STROMATOPOROIDS OF AMERICA

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PREFATORY NOTE

The species of Stromatoporoids identified from the Ordovician rocks of America are neither numerous nor well defined. Beginning with *Stromatocerium rugosum*, described by Hall in 1847, we find a series of forms, all of which present great difficulty in the interpretation of their minute structure owing to the imperfect and diverse manner of their preservation. They all, however, conform to the same general type of structure, though differing greatly in their manner of growth. Between the giant forms of *Beatricea* and the delicate incrustations of *Dermatostroma papillatum* there is an external difference of striking character; nevertheless they may all be included within the family *Labechiidae* as defined by Nicholson. The present paper deals with all the forms known to the writer from the Trenton and Cincinnatian formations; the genera *Cryptozoon* and *Archaeozoon*, of possible Stromatoporoid affinities, are not discussed. These forms as well as certain species from the Chazy, referred to *Stromatocerium* by Mr. H. M. Seely, are deferred to a later paper.

In view of the very bad state of preservation of nearly all the specimens on which the conclusions herein stated are founded, it is hoped that palaeontologists will regard with leniency any errors that may occur.

For the greater part of the material on which the present article is based the author is indebted to the following gentlemen and the institutions which they represent:

Dr R. Rathbun and Dr. Ray S. Bassler, United States National Museum.
Dr. Stuart Weller, University of Chicago.
Mr. Lawrence M. Lambe, Geological Survey of Canada.
Dr. August J. Foerste, Dayton, Ohio.
Professor Charles Schuchert, Yale University.
Dr. E. O. Hovey, American Museum of Natural History.
Dr. J. M. Clarke, State Geologist, New York.

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March 5th, 1910

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The following list comprises the more important publications dealing with Trenton and Cincinnatian Stromatoporoids, as well as some references to *Cryptozoon* and its allies:

1847—Hall (Palaeontology of New York, Vol. I) describes *Stromatocerium rugosum.*

1857—Billings (Rep. Prog. Geol. Sur. Can., 1855-1856) describes *Beatricea nodulosa* and *Beatricea undulata.*

1862—Billings (Geol. Sur. Can., Palaeozoic Fossils, Vol. I) describes *Stromatopora compacta.*

1863—Billings (Rep. Prog. Geol. Sur. Can., 1863) records and figures *Stromatopora rugosa.*

1865—Billings (Geol. Sur. Can., Palaeozoic Fossils, Vol. I) describes *Stenopora huronensis.*

1865—Hyatt (Am. Jour. Sci., Vol. XXXIX) describes *Beatricea nodulosa,* Billings, and *Beatricea undulata,* Billings.

1878—Nicholson and Murie (Jour. Linn. Soc. Zool., Vol. XIV) describe *Stromatocerium canadense.*

1878—U. P. James (The Palaeontologist, No. 1, July), describes *Stromatopora papillata.*

1878—Mickleborough and Wetherby (Jour. Cin. Soc., Vol. I), list *Stromatopora papillata,* James, *Stromatopora lyoni,* James, and *Stromatopora cincinnatiensis,* James.

1879—U. P. James (The Palaeontologist, No. 3, Jan.), describes *Stromatopora lichenoides* and *Stromatopora scabra.*

1882—S. A. Miller (Jour. Cin. Soc. Nat. Hist., Vol. V) describes *Stromatocerium richmondense* as a sponge.

1883—Foord (Geol. Sur. Can., Conts. Micro-Pal. Sil. of Canada) discusses *Labechia ohioensis.*

1884—Hall (36th Rep. N.Y.S.M.) describes *Cryptozoon proliferum.*

1884—Hyatt (Proc. Am. Ass. Ad. Sci.) concludes that *Beatricea* is a Foraminifer.

1884—U. P. James (Jour. Cin. Soc., Vol. VII) describes *Stromatopora ludlowensis, Stromatopora tubularis* and *Stromatopora subcylindrica.*

1885—Nicholson (Monograph Brit. Strom.) gives preliminary description of *Labechia ohioensis*, and makes *Stromatocerium canadense* equal *Labechia canadensis*.

1885—Seely (Am. Jour. Sci. and Arts, 3rd Ser., Vols. XXX and XXXII) describes *Stromatochetus* as a sponge with three species.

1886—J. F. James (Jour. Cin. Soc. Nat. Hist., Vol IX) discusses the synonomy of *Labechia montifera* and *Stromatopora subcylindrica*.

1886—Nicholson (Ann. and Mag. Nat. Hist., July) describes more fully *Labechia ohioensis*, which is considered synonymous with *Labechia montifera* of Ulrich, and redescribes *Labechia canadensis*.

1886—E. O. Ulrich (Contributions to American Pal., No. 1, May) describes *Labechia montifera*.

1886—Winchell (14th Rep. Geol. Sur. Minnesota) describes *Cryptozoon minnesotense*.

1889—Dawson (Can. Rec. Science, Vol. III) describes *Cryptozoon boreale*.

1890—Brainard and Seely (Bull. Geol. Soc. Am., Vol. I) describe the Cryptozoa of the Calciferous in the Champlain valley (*Cryptozoon steeli*).

1892—J. F. James (Cin. Soc. Nat. Hist., Vol. XV) lists and briefly redescribes *Stromatopora tubularis*, *Stromatopora subcylindrica*, *Stromatopora lichenoides*, *Stromatopora scabra*, *Stromatopora papillata*, *Stromatopora ludlowensia*, *Stromatopora hindii*; describes a new species, *Stromatopora indianensis*; refers to *Stromatocerium canaderse*, *Beatricea nodulosa* and *Beatric undulata*.

1897—Dawson (Can. Rec. Science, Vol. VII) reviews *Cryptozoon* and *Archaeozoon*; describes *Cryptozoon boreale*, *Cryptozoon occidentale*, *Cryptozoon lachutense*; refers also to *Megastroma laminosum* and *Girvanella* (Nicholson).

1897—Roemer-Frech (Lethaea Palaeozoica, Vol. I) suggests the identity of *Stromatocerium rugosum* and *Stromatocerium canadense*.

1897—Whiteaves (Can. Rec. Science, Vol. VII) states that *Clathrodictyon variolare* occurs at Cape Smyth and at the jumpers in Anticosti; lists *Labechia canadensis*, *Labechia huronensis*,

Beatricea nodulosa, Beatricea undulata, and *Stromatocerium rugosum.*

1899—Lambe (Ottawa Naturalist, Vol. XIII) establishes the identity of *Stenopora huronensis,* Billings, with *Labechia ohioensis,* Nicholson.

1904—Seely (Rep. Vermont State Geologist, 1903-1904) describes and figures *Stromatocerium rugosum,* also describes *Stromatocerium catoni, Stromatocerium lamottense, Stromatocerium moniliferum* and *Cryptozoon perkinsi.*

1906—Bassler (United States National Museum, Bull. XXX) removes to the Bryozoa *Stromatopora tubularis,* James, *Stromatopora lichenoides,* James, and *Stromatopora ludlowensis,* James.

1907—Cumings (32nd Ann. Rept., Rep. Geol. and Nat. Res. Indiana) lists and describes *Beatricea undulata, Beatricea nodulosa* and *Labechia montifera.*

1909—Foerste (Bulletin of the Denison University, November) records the occurence in Kentucky of *Beatricea undulata,* describes *Beatricea undulata-cylindrica, Beatricea nodulifera* and *Beatricea nodulifera-intermedia.*

ORDER—STROMATOPOROIDEA, *Nicholson and Murie*
Section A. (Hydractinoid Group)

Family—LABECHIIDAE, *Nicholson*
Genus—STROMATOCERIUM, *Hall*

Hall's original description is too meagre to be of any value in differentiating the genus at the present time, although, in a general way, it well defines the organism as known to him.

Nicholson made no close examination of the type specimens of *Stromatocerium rugosum*, but was inclined to consider it as identical with the form which he first described as *Stromatocerium canadense* and afterwards removed to the genus *Labechia*. Other authors have described species of *Stromatocerium*, but usually on the ground of superficial characters only. The determination of the minute structure is a matter of the greatest difficulty, and the following amended description is offered only after the examination of a great number of sections and the comparison of forms from different horizons. The conditions of preservation are so variable and result in such diverse appearances in section, that descriptions based on single individuals fail entirely as a means of generic differentiation. By far the best preserved specimens are those to be described as *Stromatocerium michiganense* which I should prefer to *S. rugosum* as the genotype.

The coenosteum consists of a superimposed series of laminae, which may be comparatively straight and continuous or may be bent into folds with the convexities upwards so as to be reduced to a mass of superimposed vesicles. Passing vertically through this tissue are numerous bent and angulated plates of variable horizontal extent. Sometimes these plates have a tendency to arrange themselves in a radiating manner around certain points, thus simulating the appearance of the astrorhizae of other Stromatoporoids. In some cases these vertical elements appear to have been hollow, in others there is no evidence of a cavity. Considering the state of preservation of most forms it is better to leave this point undecided. The essential difference between

Labechia and *Stromatocerium* lies in the fact that the pillars of the former genus are replaced by the vertical plates of the latter.

The range of the genus is from the Lower Trenton to the Upper Richmond, or, if we accept the forms described by Mr. H. M. Seely from the Chazy of Isle La Motte*, the range is considerably increased.

STROMATOCERIUM MICHIGANENSE, *sp. nov.*—Plate XXI, Figs. 1 and 2

As this organism is known from a few fragments only, very little can be said as to its general form or habit of growth. The present examples appear as intergrowths with *Labechia macrostyla*, and attain a thickness of at least 30 mm. The character of the surface is unknown. Dr. Rominger was aware of the specific difference of these specimens, for his label bears the following inscription, "*Stromatocerium rugosum* and another not determined fossil alternately incrusting one another."

The coenosteum consists, as in *Labechia*, of a superimposed mass of vesicles with their convexities upwards. The substance of the vesicular walls is extremely thin and they are so spaced that an average of four occurs in the space of one mm. measured vertically. Passing vertically through the mass of vesicles is a series of plates the thickness of which does not exceed .1 mm. These plates vary greatly in horizontal extent and are not straight but bent and angulated in a curious manner. They never, however, enclose a space; if they did, the structure would approach that of a tubular Bryozoan or compound Hydrozoan. It cannot be stated with certainty whether these plates are hollow or solid. They always present a clear transparent interior defined by bordering lines where the vesicles are filled with calcite, but destitute of any margin where the matrix is clay.

Vertical sections (Plate XXI, fig 1) cut three or four of the vertical plates in the space of one mm. Where the section crosses the plate at right angles it appears as a clear or slightly clouded line bordered by darker bands. Where it follows the

*H. M. Seely, The Stromatoceria of Isle La Motte, Vermont (Report of the State Geologist, Vermont, 1903-1904).

line of a plate the clouded interior only is seen. It is obvious that many intermediate sections must appear. The clear central portion of the plates is finer in structure than the coarse calcite filling the vesicles which is not reproduced in the drawing. The vesicular walls appear as fine dark lines, which have never been observed to be double, although where the interstices are filled with clay they present a much lighter section than the matrix.

Tangential sections (Plate XXI, fig. 2) exhibit the cut plates only, the vesicles being too thin to appear to any extent. Some indication of them may be observed but they are so inconspicuous that they have been omitted in the drawing. The size and shape of the elements as represented are exactly correct, but the method of representing the matrix is conventional only. It should be observed that there is no indication of the plates radiating from centres, nor has any such disposition of these elements been seen in the sections examined.

It is impossible to mistake this organism for any other, for, although a vertical section might not be convincing, the characteristic tangential section approaches in no way to any described form. The resemblance of this section to a series of polygons, communicating with each other by the absence of certain of the common sides, is very striking. Adopting this view, the whole organism might be considered as a series of polygonal tubes, crossed by arched tabulae, and communicating with each other throughout the whole length of certain of the walls. Is it possible that the genus *Labechia* arose from this type by the gradual contraction of the vertical plates into round pillars? If so, we have in this species an interesting connection between the *Labechiidae* and the tubular Hydrozoans and Corals.

Stromatocerium michiganense, rather than *S. rugosum*, is taken as the type of the genus because the preservation is much more perfect and because there is absolutely no doubt as to the shape and character of the vertical elements.

Locality.—The only specimens known are part of U.S.N.M., No. 56843, from the Lower Trenton Drift of Ann Arbor, Michigan.

STROMATOCERIUM RUGOSUM, *Hall* sp.—Plate XXI, Figs. 3, 4, 5, 6, and 7

STROMATOCERIUM RUGOSUM, *Hall*, Palaeontology of New York, vol. i, p. 48, pl. xii, figs 2, 2a, 2b, 1847.
STROMATOPORA RUGOSA, *Billings*, Geol. Sur. Canada, Report of Progress to 1863, p. 140, fig. 72, 1863
STROMATOCERIUM RUGOSUM, *Nicholson and Murie*, Jour. Linn. Soc. Zool., vol xiv, p. 223, 1878.
STROMATOCERIUM RUGOSUM, *Nicholson*, Mon. Brit. Strom., p. 83, 1886.
STROMATOCERIUM RUGOSUM *Whiteaves*, Can. Rec. Science, vol. vii, p. 143, 1897
STROMATOCERIUM RUGOSUM, *Roemer*, Lethaea Palaeozoica, p. 535, 1880-1897.
STROMATOCERIUM RUGOSUM, *Seely*, Rep. Vermont State Geologist, 1903-1904, p. 144, pl. lxx, 1904.
STROMATOCERIUM RUGOSUM, *auct.* (Many references without description.)

While I have been unable to obtain a view of Hall's types of this species, the kindness of Professor J. M. Clarke of Albany has afforded me the privilege of examining a number of sections made from "topotypes." There can be no doubt that the species is distinct from Nicholson's *Labechia canadensis*, with which it has been much confused.

Stromatocerium rugosum is described by Hall in the following manner: "Coral, hemispherical; growth in concentric laminae or strata; laminae numerous, wrinkled; some faint indication of vertical tubes or cells. This coral usually appears as a rough shapeless excrescence upon the weathered surface of the limestone; but a little examination shows it to be composed of concentric layers, which are evidently the skeleton of some coral. This coral, so far as known, is confined to the Black River limestone, and to the dark layers alternating with the Birdseye limestone. It occurs in the dark marble quarried on the east side of Ile la Motte; but this mass lies much above the *Maclurea magna*, if not higher than the Birdseye limestone. It occurs at Chazy village, Watertown and other places."

Ferdinand Roemer in *Lethaea Palaeozoica* retains the genus *Stromatocerium* with the following description:

"Die concentrischen Lagen sind nicht zusammenhängend, sondern uregelmässig angeordnet; die senkrechten Pfeiler oder Stützen fehlen. Dagegen ist die ganze Masse von unregelmässig angeordneten senkrechten Röhren durchzogen, welche keine Wände haben und viel kleiner als bei *Caunopora* sind. Die Gattungsbenennung war von J. Hall gebraucht worden; Nichol-

son und Murie begründen dieselbe aber neu, indem sie eine Art zum Typus derselben machen welche anscheinend mit Hall's *Stromatocerium rugosum* nahe verwandt oder vielleicht identisch sei. Diese Art ist *Str. canadense* aus dem Unter-Silur (Trenton limestone) im Staate Ontario."

It was this *apparent* absence of vertical elements and their replacement by wall-less tubes that induced Nicholson and Murie to retain the genus *Stromatocerium* in the description of *S. canadense* referred to by Roemer. Afterwards, however, Nicholson decided that the vertical passages represented the position of original pillars which had been altered to clear crystalline calcite; in consequence of this he removed his species to the genus *Labechia*.

Stromatocerium rugosum grows into rough hemispherical or rounded oblong forms reaching a diameter of eight inches and possibly more. The point of attachment was probably much smaller than the diameter of the adult coenosteum, but an epitheca has not been observed, although it doubtless existed. The surface, though undulating, is not uniformly provided with distinct mamelons, but much variation is seen in the character of the exfoliated exterior. The general appearance of the weathered vertical section is shown in Plate XXI, fig. 7, which was prepared from a specimen from Pauquette's Rapids, Ontario. This specimen does not, however, exhibit the minute structure of an ideal example of the species. In typical specimens the whole coenosteum is composed of gently undulating concentric laminae, about seven of which appear in the space of one mm. These laminae, in typical examples, are comparatively straight, but they may become somewhat arched and even degenerate into vesicular tissue in certain cases. Nevertheless, a characteristic of the species is the comparatively straight and continuous laminae. In many of the specimens the space between the horizontal elements is filled with structureless matter, but in several examples from Pauquette's Rapids the under side of the laminae is coated with a thick layer of granular tissue which shows a tendency to arrange itself at right angles to the lamina. In many cases it almost fills the interspace but it is invariably closely connected with the lamina above. At first I was inclined to regard this matter as foreign to the organism, but its constant

relation to the overlying lamina and its occurrence in *Labechia* (?) *canadensis* and in *Beatricea* has convinced me that it really forms part of the original coenosteum. Extremely difficult of interpretation are the vertical elements, and it is only by means of comparison with other forms, particularly with *Stromatocerium michiganense*, that the following opinion is offered.

These structures are in every case represented by apparent interspaces traversing the coenosteum radially. I am convinced that they were not originally mere pores but that they were true vertical elements, the cross section of which presents the narrow and angulated appearance characteristic of the genus.

Vertical sections (Plate XXI, figs. 3 and 4) show that the horizontal elements possess an extremely thin upper layer, which is the only part preserved in many specimens. The fine line representing the severed edges of the laminae is fairly continuous and comparatively straight in typical examples. The vertical elements appear as clear interspaces, but traces of a wall may be observed in parts of an extended section. Owing to the universally poor state of preservation, the vertical section does not reveal the character of the upright elements. Figure 3 was prepared from a specimen from Lake Champlain; it shows the thin and straight laminae but no granular matter or bordering lines to the vertical elements. Figure 4 is from a somewhat finer example from Kirkfield, Ontario, and exhibits an outline of the "pillars" as well as, in places, a fine white line in the centre of the laminae.

Polished tangential surfaces always show, though frequently in a very obscure manner, clear vermiculate lines radiating from certain centres about four mm. apart.

Tangential sections (Plate XXI, figs. 5 and 6) show such diverse appearances, according to the state of preservation, that an interpretation of the structure is very difficult. One is impressed by the resemblance of the radiating openings to the astrorhizae of higher Stromatoporoids; this is particularly noticeable in those forms with the granular tissue beneath the laminae proper. We might, therefore, interpret these openings as true astrorhizae traversing the granular tissue, but for two facts. First, they appear equally well in the sections where no granular tissue is preserved, and second, the vertical section shows no

trace of their cut canals except the *vertical interspaces*. We are forced to conclude that the obscurely radiating canals of cross section and the vertical spaces in vertical section are the same elements. The upright structures in *Stromatocerium rugosum* are therefore of the nature of angulated plates which always appear as clear calcite, but whether this calcite is the original tissue, or whether it has replaced something else, or whether it represents an original hollow centre, I am not prepared to state.

An interesting specimen from the Lexington limestone of Kentucky, which probably belongs to this species (U.S.N.M., No. 54293) presents the skeleton of the fossil in a silicified condition with the matrix removed by weathering. The vertical elements are distinctly not round. Although in pla they may approach this shape, the characteristic appearance is that of curved upright plates presenting a horseshoe-shaped cross section. A similar section is seen in part of Plate XXI, fig. 5. In this figure the dark portion is the matrix and the light part is the section of the vertical elements; the thin horizontal laminae are not apparent. In Plate XXI, fig 6, the dark part is the section of the granular layer and the clear portion the severed vertical elements together with interlaminar vacuities. In both figures the resemblance to a tangential section of *Stromatopora* is remarkable.

Although the borders of the "pillars" are very indistinctly defined by dark bands, the existence of any trace of demarcation is enough to prove that the vertical spaces were originally of solid character, at least externally. The dark bands may be the substance of the exterior of the structures or they may be only stained matrix. After death, the organic matter of the vesicles would naturally gather on the surrounding hard tissue and, on the subsequent infiltration of matrix, would impart a darker hue to the part of the infiltered substance in immediate contact with the hard tissue. Whatever may have been the original character of the upright structures I am convinced that they were not mere pores.

The most characteristic feature of the present species is the straight character of the laminae and their comparatively even spacing. Even this feature is, however, not constant, for the straight laminae are seen to degenerate into vesicular tissue. It

is very interesting, in view of certain observations to be made later on the structure of *Stromatocerium canadense*, to note that the degeneration of the laminae into vesicular tissue is accompanied by a failure of the vertical elements.

The present species is subject to variation, but well preserved examples are readily identified by the generally lineal character of the laminae. Coarser and finer examples occur; the one figured in Plate XXI, fig. 5, from Kirkfield, Ontario, has an average of four vertical elements in a mm. instead of three as in the specimens from the type locality. It must be admitted, however, that a vast number of specimens have been ascribed to this species the certain identification of which is beyond the limit of possibility.

Locality.—Black River and Birdseye limestone, Lake Champlain; Black River, Pauquette's Rapids, Ontario; Trenton, Kirkfield, Ontario; Trenton, Jones' Hill, Lebanon, Ky. (Am. Mus. Nat. Hist., No. $\frac{4}{4}$^{9}).

Doubtful examples occur in many other localities.

STROMATOCERIUM CANADENSE, *Nich. and Murie*—Plate XXI, Figs. 8 and 9; Plate XXII, Figs. 1, 2 and 3

STROMATOCERIUM CANADENSE, *Nicholson and Murie*, Jour. Linn. Soc. Zool., vol. xiv, p. 223, pl. iii, figs. 9 and 10, 1878.
LABECHIA CANADENSIS, *Nicholson*, Mon. Brit. Strom., pl. ii, figs. 3-5, 1886.
LABECHIA CANADENSIS, *Nicholson*, Ann. and Mag. Nat. Hist., ser. 5, vol. xviii, p. 14, pl. ii, fig. 5, 1886.
LABECHIA CANADENSIS, *Nicholson*, Mon. Brit. Strom., p. 163, pl. xx, fig. 9, 1891.
STROMATOCERIUM CANADENSE, *James*, Jour. Cin. Soc. Nat. Hist., p. 93, 1892.
LABECHIA CANADENSIS, *Whiteaves*, Can. Rec. Sci., vol. vii, p. 131, 1897.

Nicholson's revised description as given in the Annals and Magazine of Natural History is as follows:

"Coenosteum sometimes massive, sometimes composed of thick laminae with a basal epitheca. Surface imperfectly known but apparently possessing irregular tubercles and conical mamelons. Radial pillars large and irregularly developed. The vesicular tissue between the pillars is also very irregularly developed, the vesicles being sometimes of moderate dimensions, but being at other places of large size and irregular form. The vesicles have their convexities turned upwards, and the radial pillars terminate upwards in pointed extremities. All the examples of this species

which I have examined are in a highly mineralized condition, and are not in a state to allow of the satisfactory working out of the minute structural details. That the specimens are rightly referable to the genus *Labechia* is, however, clear, and there can also be no doubt as to the distinctness of the species. Many of the specimens which I have collected, both from America and from Russia, have the skeleton replaced by calcite; but I have here figured a vertical section of a Russian example in which the skeleton is preserved in the normal manner. The species is most clearly allied to *Labechia conferta*, Londs., but is sufficiently distinguished from it by the much more irregular arrangement of the vertical pillars, and the correspondingly irregular development, as regards both size and shape, of the interstitial vesicles."

The variation possible in this species is most remarkable. The general form of the coenosteum is so variable that any attempt to ascribe fixed characters to it is unavailing. Massive hemispherical examples are seen; flat expansions of some inches in thickness occur; encrusting forms are common and other habits and shapes have been observed. The surface likewise is devoid of any well marked characteristics. Some forms are almost smooth, others have small, well marked mamelons, while still others present prominent conical elevations, the exfoliation of which causes a ragged and somewhat vesicular appearance. With regard to the size and distribution of pillars and vesicles, the former elements have been observed to occur as close as one mm. apart or to be entirely absent; how far this variation is to be accounted for by mineralization it is impossible to say. The size of the vesicles is of absolutely no assistance in the identification of the species; forms have been observed with four vesicles to the mm. in vertical extent, and others in which a single vesicle is four mm. high. This variation is not expressed merely by different specimens, but occurs to almost the extent stated above within a single coenosteum. It is quite possible that several varieties or even species are here included under *Stromatocerium canadense*, but in view of the transitions observed and the uniformly poor state of preservation it is thought better to include them all under one specific name.

The minute structure of *Stromatocerium canadense* is very much more complicated than Nicholson's description indicates.

Plate XXI, fig. 8, shows a vertical section of a specimen in a poor state of preservation. Nothing is to be observed but the vesicular walls and the occasional pillars. Better sections (Plate XXI, fig. 9; Plate XXII, fig. 1) however reveal a more minute structure which is exceedingly interesting. Each vesicular wall consisted originally of three different kinds of hard tissue. On the inner or concave side there was present a layer of spongy or granular matter of fairly uniform thickness. In specimens, the interstices of which are filled with crystalline calcite, this layer is clearly demarcated as a granular band with a tendency for the granules to arrange themselves vertically to the lamina. Where the interstitial cavity is filled with clay, this band is never to be observed, it must therefore have been composed of spongy matter, possessing sufficient density to retain its identity when contrasted with clear, crystalline calcite, but sufficiently porous to become permeated with enough clay to make its demarcation against that more opaque material impossible. The middle layer of the vesicular wall appears as a dark, sharply defined line, which is the only part seen in specimens of ordinary preservation. The outer layer, in all sections in which it has been observed, consists of a band of clear white calcite which is extended upwards into little conical points. Sometimes these points reach the lamina above and then the structure much resembles that of the genus *Clathrodictyon*.

Although Nicholson failed to detect the above described minute structure in *Stromatocerium canadense*, he recognized the two inner layers in the cells of *Beatricea**, the structure of which appears to be identical, as far as these two layers are concerned. The close relationship of *Beatricea* and *Stromatocerium canadense* must therefore be regarded as established beyond doubt. Very interesting also is the denticulated outer layer, as it at once suggests the genus *Rosenella*. In fact, those specimens of *Stromatocerium canadense* in which the pillars largely fail would fall more naturally under *Rosenella* than under either *Labechia* or *Stromatocerium*.

As a somewhat similar structure is to be observed in certain examples of *Stromatocerium rugosum* the significance of this

*Mon. Brit. Stromatoporoids, p. 87.

minute anatomy is very great and warrants the closest attention. In the first place it must be remembered that practically all the specimens examined differ from one another in various details, such as the size of the vesicles, the frequency of the pillars, and the character of the laminae. With regard to the last feature some examples show simply a dark central line with a hazy border; others possess the three elements already described, while still a third type (Plate XXII, fig. 1) shows a clear central line with a dark margin on both sides. I am of the opinion that this upper dark line is not organic but due to the deposition of dirt on the original substance of the clear line. The lower dark line is comparatively straight and continuous but the upper one is seen to curve upwards into points and sinuosities, the white substance filling the intervening space. The upward prolongations sometimes reach the overlying lamina, in which case the white material of the upper lamina bends downward and becomes continuous with the substance of the point. By the repetition of this process, vertical elements arise which are undoubtedly composed in their interior of the same material which forms the clear part of the laminae. It is also to be observed that in those parts of the coenosteum where the tissue is very vesicular, these connecting elements are absent or appear as denticulations only on the surface of the laminae. Tangential sections (Plate XXII, fig. 2) of this type are very hard to interpret, but it appears that these papillose elevations and the resulting vertical connections are not necessarily round but of a sinuous and irregular outline. Nicholson does not state that the pillars are round nor does he figure a transverse section to show the shape of these elements. I have been unable to prepare any section revealing the ring-like cross section to be expected, and therefore conclude that the so called pillars in this species are analogous to those of the other *Stromatoceria;* consequently *Labechia canadensis* must revert to the name originally given it by Nicholson, *Stromatocerium canadense*. A further reason for this generic position is the occurrence of the granular layer in the vesicular walls, which is not seen in any *Labechia*.

Certain examples also, by the failure of the vesicular arrangement and by the tendency of the laminae to connect with each other by vertical elements, show a transition to *Stromato-*

cerium rugosum. Finally it is possible that, by the loss of the defined portion of the laminae and the development of the under spongy layer, true examples of the genus *Stromatopora* may have arisen. These conclusions are by no means susceptible of exact proof, they are merely the result of a close study of numerous sections, many of them in a state of preservation scarcely warranting any deductions whatever. It is certain, however, that starting with *Stromatocerium canadense*, one can by slight modifications derive *Labechia*, *Rosenella*, typical *Stromatocerium*, *Aulocerium*, and possibly *Stromatopora*.

So variable is this organism that the material in my hands might serve for the establishment of several varieties; the transitions, however, are so gradual and the different parts of a single specimen so unlike that no such attempt will be made. In this connection the following notes on specimens from various localities may be of interest:

Birdseye limestone, Gloucester Township, Carleton Co., Ont.—Most specimens from this locality have the surface raised into prominent elevations with a consequent upward inflection of the constituent elements. Vertical elements fail almost entirely. Parts of the coenosteum present the ordinary cystose character but other portions have straighter laminae. These specimens are the only ones which reveal all the points of minute anatomy previously described. (Plate XXI, fig. 9; Plate XXII, figs. 1 and 2.)

Black River limestone, Pauquette's Rapids, Rideau River, Ont.—These forms show large and variable vesicles and distinct though irregular pillars. The minute structure is not well revealed. (Plate XXI, fig. 8.)

Tyrone formation, Hartsville, Tenn.—Highly silicified forms with variable vesicles. Pillars not apparent.

Lower Trenton, Escanaba River, Michigan.—The vesicles are broad and flat and the vertical elements scarcely distinguishable. (U.S.N.M., No. 36031 in part.)

Lexington, Upper Mohawkian, Kentucky.—These forms really seem to constitute a distinct variety. The vesicles are comparatively small and flat and the upright elements inconspicuous or absent. The general structure is not much coarser than in *Stromatocerium rugosum* but there are no continuous laminae.

The upper surface is provided with distinct mamelons resembling those of *Stromatocerium huronense*. In fact, the variety seems to be intermediate between *Stromatocerium canadense* and *Stromatocerium huronense var. australe*. Provisionally it might be known as *Stromatocerium canadense var. minimum*. (Plate XXII, fig. 3.) (No. 11065 Yale Mus., Cedar Run and Benson Creek, Franklin Co., Ky.; U.S.N.M., Nos. 52708 and 36930 Frankfort, Ky.)

Locality.—Black River and Trenton, localities as above Nicholson's types are from Peterborough Ont. He also recognizes the species in Europe (Saak, Esthonia and Alvons. [illegible]).

STROMATOCERIUM HURONENSE, *Billings*, sp.—Plate XXII, Figs 4-10; Plate XXIII, Fig. 5

STROMATOCERIUM HURONENSIS, *Billings*, Geol. Sur. Can., Pal. Fossils, vol. i, p. 185, 1865
ALVEOLITES GRANULOSUS, *James*, Cat. Fossils Cin. Group, p. 2, 1872
TETRADIUM HURONENSE, *Foord* (in parte), Contr. to Can Cambro-Sil. Micropal., p. 25, pl. vii, figs. 1, 1a, 1883.
LABECHIA OHIOENSIS, *Nicholson*, Mon. Brit. Strom., p. 32, footnote and pl. 1, figs 1 and 2, 1885.
LABECHIA MONTIFERA, *Ulrich*, Contr. to Am. Pal., vol. i, p. 33, pl. ii, figs. 9, 9a, 1886.
LABECHIA OHIOENSIS, *Nicholson*, Ann. and Mag. Nat. Hist., p 13, 1886
ALVEOLITES ? GRANULOSUS, *J. F. James*, Jour. Cin. Soc. Nat. Hist., vol. xv p 148, fig 9, 1892.
LABECHIA HURONENSIS, *Whiteaves*, Can. Rec. Science, vol. vii, p. 131, 1897
LABECHIA HURONENSIS, *Lambe*, Ottawa Naturalist, vol. xiii, p. 170, 1899.
LABECHIA MONTIFERA, *E. R. Cummings*, 32nd Rep., Dept. Geol. Ind., The Strat. and Pal. of the Cin. Series of Indiana, p 704, pl. i, figs. 2-2b, 1907

As pointed out by Mr. Lambe, there can be no doubt that Billings was the first to attempt a description of this peculiar fossil. Although the specimen which served as the type consists of two different species, the present example forms the greater portion of the mass and is evidently the portion Billings had in view, as may be seen from the following description:

"Corallites forming large rounded masses, sometimes one foot in diameter and nine inches in height, covered with small conical elevations from two to four lines in diameter, the most prominent about two lines in height, and distant from one another from one to six lines (measuring from the centre of each). The

tubes are small, there being about four or five in the width of one line, larger on the summits of the elevations, where, also, they exhibit a tendency to an arrangement in lines radiating from the apex of the elevations. In some of the weathered sections an obscure lamellar concentric structure is exhibited, similar to that of *Stromatopora concentrica*."

With regard to the result of Foord's examination of the type specimen, I cannot do better than quote Mr. Lambe's observations:

"In one of his papers in the 'Contributions to Canadian Cambro-Silurian Micro-palaeontology,' Mr. A. H. Foord states that having made a microscopical examination of *Stenopora huronensis*, Bill., he finds that it belongs to the genus *Tetradium*. Mr. Foord gives an amended description of this species as he understands it, but unfortunately includes in it two distinct forms, under the name *Tetradium huronense*. The specimens represented on Plate VII, fig. 1, of Foord's paper, consist of a *Labechia*, the minute structure of which is well preserved, incrusting a small mass of *Tetradium fibratum*, Safford. The original of figure 1*a* is a small portion only of a large mass of the *Labechia* measuring nearly 5½ inches across. These specimens figured by Foord were those used by Billings in describing *Stenopora huronensis* and are still in the museum of the Survey. The structure is clearly shown on polished surfaces in both specimens, proving beyond doubt that the fossils belong to the genus *Labechia*, incrusting in the first instance and massive in the second.

"Dr. Nicholson's description of *Labechia ohioensis* is based upon specimens obtained by him at Waynesville, Ohio, and the Cape Smyth specimens of *Stenopora huronensis*, Bill., collected by Dr. Robert Bell in 1859. Dr. Nicholson states that in the Cape Smyth specimens the structure is much better preserved than in those from Ohio. He also mentions that Mr. Foord has drawn his attention to the fact that 'some of the appearances which he describes as characterizing *Tetradium huronense*, Bill., sp., are really due to the fact that the specimens of this coral which he examined were covered with a crust of *Labechia ohioensis*.'"

Having carefully examined the type specimens referred to

by Lambe as well as that of *Alveolites granulosus*, James, I am of the opinion that Mr. Lambe's conclusions as to the identity of *Stenopora huronensis*, Bill., *Tetradium huronense*, Foord, and *Labechia ohioensis*, Nich., are correct. To this list of synonyms we must add *Alveolites granulosus*, James, and in all probability *Labechia montifera*, Ulrich, although I have not seen the type of the last species.

In spite of the extended synonomy, to Nicholson belongs the credit of the first minute description of the species. The essentials of this description are as follows:

"Coenosteum sometimes laminar and pedunculate (?) often encrusting foreign bodies. Upper surface sometimes smooth, but more commonly with small conical mamelons, covered throughout with minute rounded or pointed tubercles. (Plate XXII, figs. 4 & 5.) Radial pillars about one-sixth mm. in diameter, and placed at distances of from one-fourth to one-third mm. apart. The radial pillars are mostly more or less angulated, and sometimes exhibit distinct traces of axial canals. The interspaces between the pillars are occupied by delicate vesicular tissue formed of minute vesicles, the convexities of which are directed towards the surface."

The fact that Ulrich lays stress on the angulated character of the pillars in *Labechia montifera*, together with the general similarity of the description to that of *Labechia ohioensis* leaves little doubt of the identity of the two species. But it must not be overlooked that Ulrich's species is essentially incrusting, while Nicholson's is more often massive.

To the descriptions quoted little can be added except with regard to the character of the vertical pillars. In vertical section (Plate XXII, figs. 6, 7 and 8) a slight difference may be observed in the size and arrangement of the vesicles, but the greatest diversity is seen in the degree of perfection exhibited by the pillars. Having examined a great number of specimens I am convinced that this difference is entirely due to varying methods of preservation. Fig. 7 is prepared from a specimen from Cape Smyth; fig. 8 represents an example from Wilmington, Ohio; fig 6 is from the type of *Alveolites granulosus*, James.

It is in tangential section however (Plate XXII, figs. 9 and 10) that one sees the peculiarities of the pillars to greater advan-

tage. Although a great number of examples have been examined, in no case was the cross section of the pillar round; in poorly preserved specimens it presents an angulated outline, but in all good specimens the cross section is so elongated and so drawn out into spurs, that the vertical element is much better characterized as an angulated plate than as a pillar. Radiating from the centre of the mamelons, the pillars come into contact with each other so as to appear as long denticulated lines. Figure 9 was prepared from a specimen from "Waynesville bed, lower part of Richmond formation, near Wilmington, Ohio," collected by Dr. George M. Austin, and presented to the author by Dr. August J. Foerste of Dayton, Ohio. This specimen is excellently preserved; numerous sections have been prepared from it and they all exhibit clearly and unmistakably the structure indicated in the figure. I am convinced that it is only by partial destruction of the characteristic vertical elements as here figured that the simply stellate cross section observed by Nicholson and others is produced. Figure 10 was prepared from the type of *Alveolites granulosus*, James. The preservation of this specimen is not good and the pillars are somewhat disintegrated, but, strange to say, the vesicular walls appear in cross section much more clearly than they do in the much better specimen shown in figure 9.

It is apparent that this characteristic type of pillar is closely allied to that presented by *Stromatocerium michiganense*, which I prefer to regard as the type of the genus. Were it not for the discovery of this latter species one might be tempted to retain the present form under *Labechia*, but in view of the existence of another type in which the characteristic structure is carried to even greater perfection we are forced to remove this much disputed species to the genus *Stromatocerium*.

Figures 4 and 5 of Plate XXII are introduced to illustrate the character of the surface and Figure 5, Plate XXIII to show the weathered vertical section

Labechia subcylindrica and *Labechia macrostyla*, as far as their surface appearance is concerned, are practically indistinguishable from *Stromatocerium huronense*. The difference is revealed only by tangential section. The distinct round pillars

of the two former species cannot be mistaken for the angulated columns of the latter.

Locality—Billings' type was obtained from the Hudson River formation (Richmond), Cape Smyth, Ontario, by Dr. Robert Bell in 1859. Nicholson's types were from the same locality and from the "Cincinnati group, Waynesville, Ohio." Ulrich's type was obtained at Madison, Indiana, and, what is probably a massive form of the same, at Clarkesville, Ohio. Mr. Cumings mentions the species as occurring in the upper part of the Richmond formation (Saluda) in the vicinity of Osgoode, Indiana. The specimens here figured from Wilmington, Ohio, are probably from the same horizon as Nicholson's types. Dr. Foerste gives the formation as "Waynesville bed, lower part of Richmond formation." Common in the Richmond formation at Streetsville, Ont. Cincinnatian, Warren Co., Ohio (U.S.N.M., No. 40077.) Upper Richmond, 1½ miles W. of Lebanon, Ky. (U.S.N.M., No. 39488.) Cincinnatian, 6 miles N.W. of Nashville, Tenn. (Am. Mus., No. 1166.) This specimen is labelled *Stromatopora pustulosa*, Safford. It presents the surface characteristics of the present species but is practically structureless.

STROMATOCERIUM HURONENSE *var.* AUSTRALE, *var. nov.*—Plate XXII, Fig. 11

A large number of examples from the Richmond formation have been examined, the identification of which is very doubtful. This is particularly true of the specimens from Tennessee and Kentucky, in which the minute structure is destroyed beyond the possibility of exact determination. There is, however, in vertical section, a similarity between all these southern forms which may indicate that they belong to a distinct variety. Tangential sections are never good enough to exhibit the characteristic pillars and consequently they are included in the present species only on account of general resemblances. The vertical section shows a somewhat coarser structure, with more widely spaced pillars (Plate XXII, fig. 11), which appear to be hollow and which fail entirely in many parts of a section, leaving the vesicular tissue only. The surface is covered by mamelons which are lower, broader and more widely spaced than in the typical

examples. The form of the coenosteum is variable, ranging from sub-hemispherical to broad explanate in general habit of growth. I propose for this form the name *Stromatocerium huronense* var. *australe*. In its coarse structure and in the variability of its pillars the form approaches *Stromatocerium canadense* but it differs in that the cross section shows distinct centres from which radiate hollow lines. This feature is never shown by *Stromatocerium canadense* but is characteristic in *Stromatocerium huronense*. The variety is represented by the following specimens from the United States National Museum: No. 49523, Upper Richmond near Lebanon, Ky.; No. 49522, labelled Cystostroma-Stellistroma, top of Cincinnati Group, 18 miles east of Louisville, Ky.; No. 49525, labelled Cryptospongia tuberosa, Ulrich, Upper Richmond, eastern part of Jefferson Co., Ky.; No. 49507, Middle Cincinnatian, Nashville, Tenn.

Genus—LABECHIA, *Edwards and Haime.*

LABECHIA MACROSTYLA, *sp. nov.*—Plate XXII, Fig. 12; Plate XXIII, Figs 1, 2, and 11

STROMATOCERIUM RUGOSUM, *Rominger*, MSS. (U.S.N.M. Labels).

The coenosteum in this species seems to have consisted of sub-hemispherical masses which attained considerable size. The point of attachment was much smaller than the diameter of the specimen and appears to have been covered by a wrinkled epitheca. In nearly all the specimens the surface is marked by distinct mamelons, which are but slightly elevated and situated from each other about 8 mm. The concentric elements fail almost entirely, being defined only at irregular intervals and there in a very incomplete manner; nevertheless, in a gross way, the concentric structure is always clearly seen on vertical surfaces. Likewise there is an indistinct division of the coenosteum into latilaminae of about 10 mm. maximum thickness.

The whole coenosteum is composed of a mass of delicate vesicles with their convexities, for the most part, directed outwards. These vesicles are rather flat, their horizontal extent being about three times their height; at certain levels they are more crowded together than at others and are consequently flatter and smaller at these points. An average of eight vesicles

occupies the space of 1 mm. measured vertically. Traversing this vesicular tissue are large persistent pillars which are so spaced that their centres are about ½ mm. apart. The pillars appear to have been traversed by an axial canal.

Vertical sections (Plate XXII, fig. 12) show the cut edges of the exceedingly delicate substance of which the vesicles are composed, the crowding of these structures at certain levels, and their somewhat laminar arrangement at intervals. In the lower part of the figure the pillars appear to be smaller and less compact than in the upper portion; whether this difference is natural or the result of mineralization I am unable to say with certainty.

Tangential sections (Plate XXIII, fig. 1) show the cross section of the pillars as round dots with little evidence of a hollow centre. An occasional connecting line may also be observed. The type specimen is of such limited extent that the arrangement of the pillars cannot be seen. Between the mamelons, they are distinctly round independent structures, but there is some evidence that they tended to coalesce in radiating lines from the centres of the mamelons. In some specimens which are not certainly members of this species, this arrangement is distinctly shown. The polished tangential surface (Plate XXIII, fig. 11) exhibits more variation in the size of the pillars and shows more evidence of these structures having been hollow.

The type specimen is beautifully preserved and the structure as above described is exhibited to perfection.

In establishing the present species I have not been unmindful of Nicholson's conclusions as to the character of the pillars in his species *Labechia canadensis* and presumably in *Stromatocerium rugosum*. Accepting his view, it might be considered that the type of *Labechia macrostyla* is only an exceptionally well preserved example of *Stromatocerium rugosum*. Dr. Rominger evidently held this opinion, for the specimens are so labelled. The vagaries of fossilization have wrought such changes in all examples of *Stromatocerium rugosum* that I am prepared to admit the possibility of the identity of the two species. There is, however, an unmistakable difference between the typical examples, which is shown more particularly in the peculiar cross section of *Stromatocerium rugosum* and the straight character of its laminae. I am further inclined to regard the species as distinct

on account of the discovery of *Stromatocerium michiganense* in which the vertical elements are undoubtedly of the character described, and in which the cross section approaches much closer to that of *Stromatocerium rugosum* than it does to a similar section of *Labechia macrostyla*.

Essential points of difference between *Labechia macrostyla* and *Labechia subcylindrica*, James, are difficult to find; were they from the same horizon I should be inclined to consider them identical. Such differences of structure as may be of value in identification will be referred to under James' species.

A number of specimens from the Drift of Ann Arbor (U.S.N.M., No. 36929) are doubtfully referred to this species. They present two varieties, a smooth and a monticulose form. The polished surface shows indications of round pillars and the laminae have largely degenerated into vesicles. A photograph of the polished surface of the form with mamelons is shown in Plate XXIII, figure 2. The dark parts of the figure represent the original substance of the fibre, which is seen to arrange itself in an obscurely radial manner around the axes of the mamelons. With still less certainty the species may be made to include badly preserved material from the Escanaba River, Mich. (U.S.N.M., No. 36931), and from Nashville, Tenn. (U.S.N.M., No. 36932).

Locality.—The only specimens which can, with certainty, be ascribed to this species are from the "Lower Trenton Drift," Ann Arbor, Mich. These specimens constitute part of No. 36929, U.S.N.M. They were collected by Dr. C. Rominger and by him identified as *Stromatocerium rugosum*.

LABECHIA SUBCYLINDRICA, *James*—Plate XXIII, Figs. 3, 4, 6, and 7

STROMATOPORA SUBCYLINDRICA, *James*, Jour. Cin. Soc. Nat. Hist., vol. vii, p. 20, fig. 1, 1884.
cf. LABECHIA MONTIFERA, *Ulrich*, Cont. Am. Pal., No. 1, May, 1886.
STROMATOPORA SUBCYLINDRICA, *J. F. James*, Jour. Cin. Soc. Nat. Hist., vol. ix, p. 39, 1887.
STROMATOPORA SUBCYLINDRICA, *Miller*, North Am. Geol. and Pal., p. 166, 1889.
STROMATOPORA SUBCYLINDRICA, *J. F. James*, Jour. Cin. Soc. Nat. Hist., vol. xv, p. 90, 1892.

The coenosteum of this species, in the type specimen, forms an incrustation about 3 mm. thick on the shell of an *Orthoceras*.

James gives in detail the shape and size of the organism, but these features can be of no value as they depend on the character of the substratum. In like manner, the mere thickness of the incrustation can be of little diagnostic importance, as repeated growths might build up a more massive coenosteum after the manner of other species. The whole surface is covered with papillae which are about 1 mm. apart, and is raised into distinct mamelons which average 5 mm. from centre to centre. On the slopes of the mamelons the papillae are seen to coalesce into radiating ridges (Plate XXIII, figs. 3 and 6).

On the surface of the *Orthoceras* lies a flat, basal, structureless sheet from which pillars pass outwards through the whole thickness of the coenosteum. These pillars are imbedded in a mass of delicate vesicular tissue, formed of curved sheets with their convexities directed outwards.

The pillars terminate on the surface as papillae, they were probably traversed by an axial canal, but the evidence on this point is not convincing.

Vertical sections (Plate XXIII, fig. 4) show the cut walls of the vesicles as flat, or but slightly curved lines connecting the pillars. These latter structures are rather too closely spaced in the drawing, which is due to the fact that it was prepared from a somewhat thick section. In thinner sections only three pillars occur in the space of 1 mm.

Tangential sections (Plate XXIII, fig. 7) exhibit the cut ends of the pillars as round or slightly angulated dots, which are connected by occasional curved lines representing the severed connecting elements. J. F. James regarded the present species as identical with *Labechia montifera* of Ulrich, which in its turn has to yield precedence to Nicholson's *Labechia ohioensis*, and finally this last name is probably a synonym for *Tetradium huronense* of Billings. While admitting the identity of the species of Nicholson, Ulrich and Billings, I believe that *Labechia subcylindrica* is a separate species for the following reasons. First, the pillars are large and are composed of somewhat porous tissue which is not pierced by a conspicuous axial canal; more particularly, they are round or but slightly angulated, whereas in the other species mentioned above the pillars are characterized beyond all else by their angularity and their habit of coalescence.

Second, the horizontal elements are somewhat stouter and are less arched than in the other species.

Labechia subcylindrica very closely resembles *Labechia macrostyla*. It may, however, be distinguished by the following characteristics. First, the incrusting habit. Second, its somewhat finer structure, particularly with regard to the pillars. Third, the thicker laminae. Fourth, the nearness of the mamelons to each other and their sharper definition.

Locality.—Cincinnatian, near Morrow, Warren Co., Ohio (Walker Museum, University of Chicago, No. 1199).

Genus—CHALAZODES, *Parks*

The above genus is described on page 33 of "Niagara Stromatoporoids" and was established for the reception of certain forms from Lake Huron and from Kentucky. Through a regrettable oversight I had failed to notice a footnote on page 160 of Nicholson's Monograph in which he proposes the name "*Lophiostroma*" for a European form presenting precisely the same structure as my genus; *Chalazodes*, as previously defined, must, therefore, be abandoned and the following corrections be made:

Chalzodes granulatum becomes *Lophiostroma granulatum*.

Chalazodes magnum becomes *Lophiostroma magnum*.

Chalazodes spindicandum becomes *Lophiostroma spindicandum*.

Chalazodes romingeri becomes *Lophiostroma romingeri*.

Genus—DERMATOSTROMA, *gen. nov.*

The forms included in this genus present a papillose surface exactly resembling that of *Lophiostroma* (*Chalazodes*) but they differ from that genus in the thinner coenosteum and the almost complete obliteration of the pillars as distinct elements.

The coenosteum consists of a thin continuous sheet of calcareous matter, usually investing a foreign body. It is covered with minute, close-set papillae giving to the whole surface a hail-like aspect as in *Lophiostroma* (*Chalazodes*) and in many species of *Labechia*. The internal structure of the coenosteum is not well revealed by any of the numerous sections made: it does not,

however, show the structure either of *Labechia* or of *Lophiostroma*, for it presents neither distinct pillars connected by vesicular tissue nor spongy pillars crossed by the successive horizontal sheets. The basal expansion of *Labechia* is very like an example of the present genus, consisting, as it does, of a continuous horizontal expansion with numerous papillae on the surface. These papillae of the young *Labechia* rise into pillars with the further growth of the organism, but in *Dermatostroma* there is no distinct development of pillars at all, the growth being arrested with the completion of the basal expansion. In some forms, however, there is a repetition of these sheet-like growths with irregular cavernous interspaces between.

Many of the forms here included have previously been ascribed to *Labechia*, but the complete absence of vesicular tissue and distinct pillars renders necessary their removal to the new genus.

The type of the genus is *Dermatostroma* (*Labechia*) *papillatum*, James.

DERMATOSTROMA PAPILLA[illegible]M, *James* sp.—Plate XXIII, Figs. 8, 9 and 10

STROMATOPORA PAPILLATA, *James*, The Palaeontologist, No. 1, p. 1, 1878.
STROMATOPORA PAPILLATA, *Mickleborough and Wetherby*, Jour. Cin. Soc. Nat. Hist., vol. i, p. 81, 1878.
STROMATOPORA PAPILLATA, *J. F. James*, Jour. Cin. Soc. Nat. Hist., vol. xv, p. 91, 1892.
LABECHIA PAPILLATA, *Auctores*.

The amended description as given by J. F. James is as follows.

"Cœnosteum a thin crust on corals, shells, etc. Outer surface with small, closely set, prominent papillae or tubercles; giving a granular appearance: papillae with or without circular openings at the apices; 6 to 8 papillae in one line, the interspaces non-poriferous."

Sections add little to our knowledge of the anatomy of this form, as they all show a continuous calcareous mass below the level of the papillae. There is, however, a faint line of demarcation around each pillar indicating that these structures were separate elements from the substratum up. The pillars seem to have come in contact with each other to form the basal expansion.

but a very faint indication of a fine reticular connecting substance can be made out in some cases. Where the coenosteum is very thin, the papillae seem to be arranged in rows. Plate XXIII, fig. 10, presents a tangential section; the upper portion shows the severed papillae above the level of the basal expansion, while the lower portion reveals the tissue of the underlying Brachiopod. The surface appearance of the type specimen of the natural size is represented in Plate XXIII, fig. 8, while Plate XXIII, fig. 9, shows the same surface magnified 1.7 times.

Locality.—The holotype is labelled "Cincinnatian, Cincinnati, Ohio." (Pal. Col., Walker Museum, Univ. of Chicago, No. 160.) James gives Cincinnati, Lebanon, Blanchester, etc., Ohio. The specimen from which sections were made is from the Waynesville bed, Clarksville, Ohio, collected by Dr. Geo. M. Austin and presented to the University of Toronto by Dr. August J. Foerste. (Pal. Mus., Univ. of Toronto, No. 815 HR.)

DERMATOSTROMA PAPILLATUM DIVERSUM, *var. nov.*—Plate XXIII, Fig. 12

A single specimen, U.S.N.M., No. 56844, presents a surface appearance different from any other form in that the papillae are extremely variable in size. The finer parts are very like *Dermatostroma papillatum*, but much larger papillae than are shown by the type of the species occur in places. There are no well defined monticules or rugosities and the coenosteum is incrusting on a species of *Orthoceras*. It seems advisable to establish a variety for the reception of this form.

Locality—Cincinnatian (Lorraine), Cincinnati, Ohio. (U.S.N.M., No. 56844.)

DERMATOSTROMA SCABRUM, *sp. nov.*—Plate XXIV, Figs. 1, 2 and 3

STROMATOPORA SCABRA, *James*, The Palaeontologist, No. 3, p. 18, Jan., 1879.
STROMATOPORA SCABRA, *J. F. James*, Jour. Cin. Soc. Nat. Hist., vol. xv, p. 91, 1892.
LABECHIA SCABRA, *Harper and Bassler*, Cat. Foss. Trenton and Cin. Periods in the Vicinity of Cincinnati, p. 3, 1896
LABECHIA SCABRA, *Auctores.*

The description given by James follows:—

"Coenosteum a thin crust on foreign bodies (shells or

corals) one line or less thick, made up, apparently, of very thin laminae; surface marked with prominent, conical or elongated monticules, one-half line to a line high, and from one to two lines apart; entire surface covered with closely set papillae, generally with small circular openings at the apex; varying in size from one to two inches square." (Plate XXIV, figs. 1 and 3.)

The general surface of this species does not differ essentially from that of *Dermatostroma papillatum*. The papillae are less evenly placed and less regular in size and I have not observed any indication of a tendency to coalesce into rows except in a radiating manner from the centres of the monticules. These structures are very differently spaced in different specimens and appear to be induced, in some cases at least, by elevations or other predisposing influence on the part of the underlying material. Many specimens referred to the species are doubtless *Dermatostroma papillatum* incrusting monticulose Bryozoa; and I was inclined at first to regard the monticules in all examples as due to this cause. Cases, however, occur with distinct monticules on a perfectly smooth substratum. Vertical sections through such a specimen show that the monticule is quite independent of the underlying substance. Nevertheless, I believe that the exact position of the elevated points is determined, in many cases, by determinating conditions of the underlying material. For instance, the monticules shown in Plate XXIV, figs. 1 and 3, are seen to follow the ribs of a shell of *Byssonychia* although there are no prominent elevations along those ribs to determine the distance apart of the monticules. In consequence of these facts it becomes very difficult always to discriminate between *Dermatostroma papillatum* incrusting a monticulose surface and true examples of *Dermatostroma scabrum*.

The most fortunate vertical section which I have been able to prepare (Plate XXIV, fig. 2) shows no trace of the construction of the crust from "very thin laminae." There is, however, an indication of a continuous basal expansion which is separated from the upper crust by cavernous tissue. The substance is the same throughout and often presents a continuous structureless mass from the bottom to the top of the crust.

The monticules seem to arise by the crowding together and elevation of a number of papillae whereby the identity of the

latter is lost. Vertical sections show that these elevations are quite cavernous within

The surface of a specimen encrusting *Byssonychia* is shown of the natural size in Plate XXIV, fig. 1, and enlarged 1.7 times in figure 3.

Locality.—Cincinnatian, Cincinnati, Lebanon, Blanchester, etc., Ohio. Cincinnatian (Utica), Covington, Ky. (U.S.N.M., No. 40078). Cincinnatian, Warren Co., Ohio (U.S.N.M., No 40080). The vertical section figured is from a specimen from Blanchester, Ohio (Walker Mus., Pal. Col., Univ. of Chicago, No. 1555). The figures of surfaces were prepared from a specimen from Warren Co., Ohio (U.S.N.M., No. 40080)

DERMATOSTROMA GLYPTUM, *sp. nov.*—Plate XXIV, Figs. 4, 5 and 6

LABECHIA GLYPTUS, *Foerste*, 1.38

The coenosteum in this species forms a crust from two to three mm. thick and is composed of vertical pillars, which have become confluent either in life or by the deposition of interstitial calcite during the process of fossilization. Having a greater thickness than the species already described it lends itself better to microscopical examination, so that some of the conclusions here given may, by analogy, apply to the thinner forms of *Dermatostroma papillatum* and *D. scabrum*.

The surface (Plate XXIV, figs. 4 and 5) is covered with papillae, as in the other species, but they are somewhat larger and farther apart. The papillose surface is however rendered inconspicuous by the development of numerous "monticules" which are situated from each other about 1.5 or 2 mm. Further, these monticules sometimes become confluent, so that the surface is marked by star-shaped, linear and vermiculate ridges which occupy about as much space as the intervening papillose depressions.

Vertical sections show a solid continuous mass of calcite, which is, however, marked by indistinct lines passing vertically through the coenosteum in the depressions and radiating outwards and upwards where the section cuts a monticule. In the axis of

the monticule there is also a faint appearance of superimposed arched laminae.

Tangential sections (Plate XXIV, fig. 6), show a series of irregular polygon with dark centres which present a radiating structure. The polygons are demarcated by fine lines which are not organic but which result from the apposition of neighbouring columns. The darker and better defined portions of the figure are due to silicification, the silica having replaced the original calcite in spherical concretions throughout the coenosteum.

The interpretation of the appearance of both vertical and tangential sections is assisted by a comparison with *Chalazodes* (*Lophiostroma*) *magnum* and with *Syringostroma niagarense**. In the case of these species I have proved to my satisfaction that the fine perpendicular lines in vertical section and the polygonal network in cross section are due to the apposition of original pillars by secondary deposition of calcite. There seems to be no reason why the same explanation should not be applied to the precisely similar appearance of the sections of the present species.

Locality.—The holotype was collected by Dr. G. M. Austin in the top of the Whitewater bed, Dutch Creek, near Wilmington, Ohio, and was presented to the University of Toronto by Dr. August J. Foerste. (Pal. Mus. Univ. of Toronto, No. 816 H.R.) Base of Richmond, Warren Co., Ohio. (U.S.N.M., No. 56845.)

DERMATOSTROMA CORRUGATUM, *sp. nov.*—Plate XXIV, Figs. 7, 10, 11 and 14

LABECHIA CORRUGATA, *Foerste*, MSS.

The coenosteum consists of a flat expansion from 3 to 4 mm. in thickness, which appears to grow on both sides of a median plane, so that the habit of the organism must have been frondescent.

This division of the coenosteum into two outwardly facing halves is shown in section simply by a line of separation or by a thin sheet of infiltered calcite. The entire thickness of the frond is consequently 8 mm.

The surface is covered with large and prominent papillae

*Niagara Stromatoporoids, p. 39 (211) and p. 53 (225.)

which are from ½ to 1 mm. apart, whereas three papillae occur in the space of 1 mm. in *Dermatostroma papillatum*. Indistinct monticules are present but the characteristic feature of the surface apart from the large size of the papillae (Plate XXIV, figs. 7 and 14) are the vermiculate ridges which stand up 2 or 3 mm. above the intervening depressions, in the bottom of which the crust cannot be more than 1 or 2 mm thick. The summits of the ridges are quite sharp and are marked by a distinct dividing line. The ridges do not therefore appear to be coalesced monticules but rather suggest the idea that they are due to the organism growing outward from various centres and turning upward where the different expansions came into contact

Vertical sections (Plate XXIV, fig. 11) show very much the same appearance as *Dermatostroma glyptum* and present likewise spherical concretions of silica. The lines of contact of the original pillars are seen, and, in some cases, a darker vertical stripe marking the centres of these structures.

Tangential sections (Plate XXIV, fig. 10) show the same polygonal network presented by *Dermatostroma glyptum* and also dark spots with obscure radiating structure in the centres of the polygons.

Locality.—Top of Whitewater bed, Dutch Creek near Wilmington, Ohio. Collected by Dr. G. M. Austin and presented to the University of Toronto by Dr. August J. Foerste. Holotype (Pal. Mus., Univ. of Toronto, No. 817 H.R.).

DERMATOSTROMA CANALICULATUM, *sp. nov.*—Plate XXIV, Figs. 8 and 9

The holotype forms a thin expansion on the shell of an *Orthoceras*. The basal lamina is less than a millimetre in thickness but the prominent monticules rise to a total thickness of 3 mm. The surface is covered with papillae to the number of three in the space of 1 mm. They are therefore spaced about the same as in *Dermatostroma papillatum* and in *D. scabrum*. The monticules are so large, and occupy so considerable a portion of the surface, that the intervening space appears as channels between the elevations. This form approaches close to *Derma*

tostroma glyptum, but it may be distinguished by the larger size and greater elevation of the monticules and by the fact that these structures are themselves papillose, whereas in *Dermatostroma glyptum* the elevations are smooth.

No sections have been prepared, as I have hesitated to cut up a small and unique specimen not belonging to the University of Toronto. I believe, however, that no more minute structure would be revealed than has been afforded by the other species sectioned.

Locality.—Cincinnatian, Lower Third, Waynesville, Ohio (Holotype, U.S.N.M., No. 40082.)

DERMATOSTROMA CAVERNOSUM, *sp. nov.*—Plate XXIV, Figs. 12 and 13.

The coenosteum has a maximum thickness of about 3 mm. and, although it is essentially incrusting on ramose Bryozoa, it seems, in part, to have been capable of independent growth. The surface is studded with minute papillae which occur to the number of three in the space of 1 mm. This distribution of papillae is about the same as in *Dermatostroma papillatum;* in some cases they appear to be more remote on account of their much smaller size, but in others they are indistinguishable from those of *Dermatostroma papillatum*. The whole surface is irregular and corrugated as if the thin sheets had parted from the substratum and turned up into bifoliate expansions, after the manner of *Dermatostroma corrugatum*. In addition to these features the surface is uneven, suggesting the appearance of broken blisters. The specimens are much weathered and on this account present a unique appearance in places. The papillae have disappeared and in their place little circular depressions appear which are marked in the centre by a minute remnant of the original pillar (Plate XXIV, fig. 12).

The preservation is so bad that sections are extremely unsatisfactory (Plate XXIV, fig. 13). There is enough evidence however to show that the crust is not a continuous structure but is composed of constituent laminae which are about 2 mm. in thickness. These layers are not independent but are fused with each other at intervals so as to leave lenticular inter-

spaces between them. The upper surface of each vesicle is papillose like the exterior. It is the disruption of the vesicles that gives to the surface the characteristic blistery appearance. Minute as this organism is, one is impressed with its similarity to *Roşcnella;* further, its constituent vesicular walls are somewhat similar in structure to those of *Stroma* [illegible]. In view, however, of its minute size, its papillose exterior, and its general resemblance to *Dermatostroma*, it seems better to include it in that genus.

Locality.—Trenton, base of Carthage limestone, 5 miles east of Mount Pleasant, Tenn. (U.S.N.M., No. 40508.)

Genus—BEATRICEA, *Billings*

BEATRICEA, *Billings*, Geol. Sur. Can., Rep. Prog., 1856, p. 343, 1857.

Professor Nicholson has so fully discussed this remarkable genus that his description which follows needs no enlargement.

"Coenosteum in the form of cylindrical or angulated stems, which are nearly straight, are unbranched, and may attain a great size. (Billings states that specimens are sometimes over ten feet in length and more than a foot in diameter.) In the centre of the coenosteum, running along its whole length, is a large axial tube, crossed by strongly curved calcareous partitions, or tabulae, the remainder of the skeleton being composed principally of lenticular calcareous vesicles, arranged in concentric layers round the axial canal (Plate XXV, figs. 2 and 3). Well preserved specimens exhibit radial pillars, resembling those of the Stromatoporoids generally which intersect the vesicular tissue of the skeleton, and are directed outwards in a radiating manner from the axial tube towards the surface. No zooidal tubes are certainly known to exist. The surface is ridged, or covered with elevated and usually elongated projections or mamelons (Plate XXV, figs. 1, 6, 7, 8, 9 and 10). There is no external calcareous membrane such as would correspond with the "epitheca" of a Rugose Coral.

"The fossils for which Mr. Billings proposed the name of *Beatricea* are of a most anomalous character, and have been assigned to very different positions in the animal kingdom by different observers. Most generally they have been regarded as

aberrant types of the Rugose Corals, and have been placed in the neighbourhood of the genus *Cystiphyllum*, a view which is borne out by the broad features of their skeletal structure, but which is rendered untenable by a study of the microscopic characters of the same. They have been referred by Professor Winchell to the Stromatoporoids; but I have not succeeded in finding any published account of this view, or of the grounds upon which it was based. The most recent opinion upon the subject of the affinities of *Beatricea* is that of Professor Hyatt, who formerly referred the genus to the *Cephalopoda*, but who has been led to the conclusion that it is properly to be placed among the *Foraminifera* ('Amer. Assoc. for the Adv. of Sci.,' 1884).

"My own studies upon *Beatricea* have been based in part upon specimens from the Cincinnati Group of Kentucky, and partly upon a number of very interesting examples which my friend Mr. Whiteaves, the accomplished palaeontologist to the Geological Survey of Canada, was good enough to send me. These latter were obtained from the Hudson River formation of Anticosti and of Rabbit Island, Lake Huron. The two species originally described by Mr. Billings, viz. *B. nodulosa* and *B. undulata*, were both represented in the material which I have examined.

"One of the great difficulties connected with the study of *Beatricea* arises from its apparently uniformly poor state of preservation. The skeletal tissue seems to have been very delicate and apparently very readily dissolved; hence the central portions of the coenosteum are very commonly more or less largely replaced by calcite, while larger or smaller tracts throughout the skeleton are either similarly replaced, or are completely broken up. Moreover, even where the actual structure of the skeleton has been retained, it seems to have undergone some secondary change which has rendered its interpretation exceedingly difficult, certain parts of all the sections which I have prepared always showing a cloudy and granular aspect by which the minute details are hopelessly obscured

"The two conspicuous features in the skeleton of *Beatricea*, as displayed by transverse or longitudinal sections of the cylindrical coenosteum (Plate XXV, figs. 2 and 3), are the axial tube and the peripheral vesicular tissue. The axial

tube is a longitudinal canal, generally 5 to 6 mm. in diameter, running the entire length of the cylindrical coenosteum It has no definite walls, but is formed by the superposition of a series of deeply convex vesicles of large size, the convexities of which are all turned in one direction (Plate XXV, fig. 3). Whether the convexities of these curved tabulae point to the distal or to the proximal end of the coenosteum I am unable to say, but I incline to think that they point to the former.

"The remainder of the skeleton is formed by a thick sheath of vesicular tissue, formed of lenticular calcareous cells, arranged in successive concentric zones round the axial canal and having a general long diameter of from 1 to 3 mm., their convexities being uniformly turned towards the exterior of the cylinder. The general character of the vesicles, superficially at any rate, is very similar to that of the cellular tissue of *Cystiphyllum;* and, if we take the axial canal as representing a central tabulate area, there would be considerable ground for regarding *Beatricea* as an ally of the Cystiphylloid Corals.

"The structure of the vesicles is, however, not so simple as might at first sight appear. In all thin sections, in whatever direction they may be taken, the interior of the vesicles is more or less extensively occupied by ill defined granular calcareous matter, which, beyond doubt, belongs to the skeleton of the fossil. Sometimes the entire cavity of the vesicle is filled with this granular tissue, but more often the vesicle is only lined with it, the lining being often confined to the convex margin of the vesicle, the rest of the space being filled with calcite. That this granular tissue is properly part of the coenosteum, and not a mere product of mineralization, is shown by two facts. In the first place, in certain specimens, towards the exterior of the cylinder, the walls of the vesicles disappear to a larger or smaller extent, and then the granular matter which lined them forms a series of concentric laminae, resembling the 'laminae' of an ordinary Stromatoporoid. In the second place, most specimens have this granular material in the interior of the vesicles so arranged as to leave a larger or smaller number of clear lines which radiate from the convex outer margins of the vesicles towards their shorter inner sides (Plate XXV, fig. 5). This is one of the points concerning which one is unfortunately left in

the dark owing to the imperfect preservation of the specimens; for out of a large series of sections, taken tangentially, transversely, and longitudinally, I fail to find one in which this structure is so clearly shown as to allow of a definite interpretation of its nature, though all show it more or less. All that I can say is that it reminds one, to some extent, of the arrangement of the rudimentary radial pillars on the surface of the vesicles of *Rosenella macrocystis**.

"The most characteristic structures of the Stromatoporoids, however, are the 'radial pillars,' and I am now able to show that apparently similar structures exist in *Beatricea* in a well marked form. Here, again, we have the disappointing fact that these structures, owing to the state of preservation of the specimens, are not uniformly to be recognized. Even in specimens in which they are well shown they are only to be found in portions of the coenosteum, having apparently disappeared elsewhere; or if they are present the ordinary vesicular tissue is apt to be wanting. In certain specimens, however, the vesicles and the radial pilars are preserved in the same section (Plate XXV, fig 4), in which case the pillars are seen as strong, apparently hollow rods, which are directed outwards in a radiating manner from the axial canal towards the circumference, and which are united to one another by the vesicular tissue. In this case, therefore, the structure is essentially the same as is observed in the genus *Labechia*, E. and H.

"In another very large specimen, for which I am indebted to Mr. Whiteaves, the inner layers of vesicular tissue, in the vicinity of the axial canal, show no traces of the radial pillars; but these latter structures are very well preserved in the peripheral zone of the coenosteum. Transverse or longitudinal sections of this region of the skeleton show a general structure quite similar to what we might expect in any Stromatoporoid Such sections show a series of strong radial pillars radiating from the central portion of the skeleton towards the circumference, and united by well marked concentric 'laminae,' which undulate in conformity with the surface-elevations. Both the

*In one section of *Beatricea nodulosa*, Bill., I have noticed perpendicular calcareous septa crossing the vesicles but whether or not this has anything to do with the appearances described above I am unable to say

pillars and the laminae are composed of granular matter, showing well marked dark points. The ordinary vesicles are present here and there among the pillars, and run parallel to the laminae; but they are mostly wanting, in which case the concentric laminae seem to be formed out of the granular lining which is seen in all the vesicles. Tangential sections, taken close to the circumference, also show appearances very similar to that of corresponding sections in an ordinary Stromatoporoid, such as any species of *Clathrodictyon*. We see, namely, a number of close-set, rounded or oval, granular masses which represent the ends of the transversely divided radial pillars. These are also highly granular, and they are sometimes unquestionably hollow, though at other times they appear to be solid. The section further shows curved tracts of dark granular matter, formed by the close apposition of the cut ends of the pillars, and representing the points where the plane of the section corresponds with the plane of one of the undulating concentric laminae

"Lastly, the surface of this remarkable specimen exhibits innumerable small rounded apertures, of which some are larger than the others, and are arranged in irregular longitudinal lines, which have seemingly a tendency to assume a spiral direction. The larger openings are, almost certainly the apertures of the hollow radial pillars, and possibly all are of this nature. I cannot be sure, however, that these openings are not the result of the removal of the outermost layer of the skeleton. No traces of similar openings can be detected on the surface of most specimens of the same species (*B. nodulosa*, Bill.), though their absence may only be due to their bad state of preservation

"It need only be added that though the other species of *Beatricea* described by Billings, viz. *B. undulata*, is distinguished from *B. nodulosa* by its external form, its general structure is precisely the same. I have not, however, succeeded in recognizing definite radial pillars in *B. undulata*, though I do not doubt they would be found were a sufficiently large series of specimens examined by means of thin sections.

'Upon the whole the balance of evidence seems to me to be in favour of regarding the genus *Beatricea* as an abnormal type of the Stromatoporoids. I do not recognize any Foraminiferal affinities in it; and there are various points in its structure,

as above described, which seem quite incompatible with its being a Cystiphylloid Coral. On the other hand, it presents many of the features of the Stromatoporoids. This is especially the case as regards its possession of 'radial pillars,' and when these structures are combined with vesicles, the appearances presented are hardly distinguishable from what is observable in sections of *Labechia*. Moreover, one of its most abnormal features, namely, the possession of an axial tabulate tube, finds a parallel in the genera *Idiostroma*, *Stachyodes*, and *Amphipora*. I was, indeed, at first disposed to place it in the family *Idiostromidae*, on the ground of this peculiarity alone; but the general structure of its tissues is such that, if it be regarded as one of the Stromatoporoids, it would seem to find its most natural place in the neighbourhood of the genera *Labechia* and *Rosenella*. The genus *Beatricea*, in fact, occupies with regard to *Labechia* the same place that the genus *Idiostroma* does to *Stromatopora*. It may, however, be a question, whether, in view of its numerous peculiarities, it would not be expedient to regard *Beatricea* as the type of a special family."

Regarding *Beatricea*, Mr. Thomas C. Weston* says: "After seeing many hundreds of these forms *in situ*, I quite agree with Billings in giving it a vegetable origin, and think it will ultimately be described as a fucoid. I have never seen a perfect specimen of *Beatricea*. The base or root of this plant-like form is frequently met with, but the upper end is always broken and does not show the termination, so at present we do not know what length the fossil attained. The longest section seen by me measured twenty feet and was about six inches in diameter, while fragments of others measured a foot in diameter."

The sections of *Beatricea* that I have prepared confirm all of Nicholson's conclusions; I am unable to distinguish the species by any peculiarities of ultimate structure. Specific differentiation must therefore rest on superficial characters only, and these are so variable, even within an individual coenosteum, that the limitation of species stands on very insecure ground. I have

*Reminiscences among the Rocks. Warwick Bros. & Rutter, Toronto, 1899.

specimens which show in different parts the typical structure of both of Billings' species and others in which the nodes of the one and the undulations of the other are distributed over the whole surface (Plate XXV, figs. 1 and 7).

A very fine specimen, in the possession of the Hamilton Scientific Association, presents a surface appearance different from anything described by Nicholson, but referred to by Billings, in that the exterior is covered with papillae instead of minute perforations (Plate XXV, fig. 1). This is probably the normal condition of the surface as it is similar to that presented by the allies of the genus. The perforations of Nicholson are probably due to weathering.

BEATRICEA UNDULATA, *Billings*.—Plate XXV, Figs. 1, 6, and 7.

BEATRICEA UNDULATA, *Billings*, Geol Sur. Can., Rep. Prog. 1856, p. 344, 1857.
BEATRICEA UNDULATA, *Billings*, Can. Nat. and Geol., ser. 2, vol. ii, p. 405, fig. 1, 1865
BEATRICEA UNDULATA, *Hyatt*, Am. Jour. Sci., vol. xxxix, p. 266, 1865.
BEATRICEA UNDULATA, *Nicholson*, Mon. Brit. Strom., pp. 88 and 89, 1886.
BEATRICEA UNDULATA, *J. F. James*, Jour. Cin. Soc. Nat. Hist., vol. xv, p. 95, 1892
BEATRICEA UNDULATA, *Harper and Bassler*, Cat Foss Trenton and Cin Periods in the vicinity of Cincinnati, p. 2, 1896.
BEATRICEA UNDULATA, *Whiteaves*, Can. Rec. Sci., vol. vii, p 133, 1897.
BEATRICEA UNDULATA, *Cumings*, 32nd Rep. Dept Geol. and Nat. Res., Indiana, p. 701, pl. 1, fig. 1, 1908.
BEATRICEA UNDULATA, *Foerste*, Bull. Denison Univ., p. 298, November, 1909.
BEATRICEA UNDULATA, *Knott*, Geol. of Marion Co., Ky., p. 32.
BEATRICEA UNDULATA, *Auctores*

"The surface of this species is sulcated longitudinally by short, irregular, wave-like furrows from two lines to one inch across, according to the size of the specimen. In other respects it appears very like *Beatricea nodulosa*. The largest specimen is ten feet five inches in length, about eight inches in diameter at the large end, and six inches and a half at the smaller extremity. Another short fragment is fourteen inches in diameter." (Billings.)

Dr. Foerste states that, in specimens from Kentucky and Indiana, the folds frequently assume a spiral direction, and that these examples do not exceed 60 mm. in diameter. By the loss of the longitudinal ribs the form seems to fade into a smooth variety which he has named *Beatricea undulata cylindrica*. The specimen figured (Pl. XXV, fig. 6), is from Marion County,

Ky. (Am. Mus. Nat. Hist., No. 1163.) The cross section shows the characteristic vesicles with radial pillars towards the periphery. Plate XXV, fig. 1 was prepared from a specimen belonging to the Hamilton Scientific Association; it shows the most perfect exterior that I have seen. In addition to the longitudinal folds, characteristic of the species, the surface is drawn up into scattered nodes resembling those of *Beatricea nodulosa*. Minute papillae, instead of the pits described by Nicholson, are uniformly developed over the whole surface. This specimen is 75 mm. thick and presents in cross section a series of concentric layers of very different aspect. The inner tube has a radius of only 3 mm. This is surrounded by a ring, 20 mm. thick, of ordinary vesicular tissue with the granular element well developed but with scarcely a trace of radial pillars. Surrounding this ring is an outer zone, 15 mm. thick, which is fairly well demarcated by a sharp line of separation. This outer layer is strikingly different from the middle annulus, being composed of continuous laminae and well marked radial pillars. Small patches of the ordinary vesicular tissue are, however, to be seen in places particularly in the hollows between the longitudinal ridges. So different is this outer zone and so sharp the line of demarcation that one would certainly conclude that it belonged to another organism if it were not for the occasional presence of the patches of ordinary tissue.

Locality.—Hudson River, Cape James, Table Head, and other localities in Anticosti; Snake Island, Lake St. John, P.Q., Rabbit and Club Islands, Lake Huron; Stony Mountain, Manitoba; Marion, Nelson, Madison and Bullitt counties, Ky.; Richmond and various localities in the Saluda formation of Indiana; numerous localities in Ohio and generally throughout the Cincinnatian formations.

BEATRICEA UNDULATA CYLINDRICA, *Foerste*.

BEATRICEA UNDULATA CYLINDRICA, *Foerste*. Bull. of the Denison University, p. 298, pl. ix, fig. 7, November, 1909.

Dr. Foerste's description is here reproduced without comment:

"In typical specimens of *Beatricea undulata* the vertical

ridges and intervening grooves are at least sufficiently distinct to be detected readily. Occasional specimens occur destitute of both ridges and nodes. These may be only extreme variants of *Beatricea undulata*, and here are figured as *Beatricea undulata-cylindrica*.

"*Geological position.* Four miles north of Richmond, Kentucky, half a mile north of Ophelia, in strata corresponding to the southern extension of the Liberty bed as exposed in Boyle, Casey, Marion, Washington, Nelson, and Bullitt counties. At Ophelia this smooth form of *Beatricea* is associated with *Beatricea undulata*, *Beatricea nodulosa*, *Labechia ohiocnsis*, *Columnaria alveolata*, *Calapoecia cribriformis*, *Streptelasma vagans*, *Platystrophia acutilirata*, and other fossils. Similar specimens have been found at the same horizon immediately west of Fredericktown, in Nelson County, and in the northeastern part of Raywick, in Marion County, Kentucky; also in the Elkhorn bed, along Elkhorn Creek, south of Richmond, Indiana."

BEATRICEA NODULOSA, *Billings.*—Plate XXV, Figs. 2, 3, 4, 5, 7 and 8

BEATRICEA NODULOSA *Billings* Geol. Sur. Can., Rep. Prog. 1856, p. 344, 1857
BEATRICEA NODULOSA, *Hyatt* Am. Jour. Sc., vol. xxxix, p. 260, 1865
BEATRICEA NODULOSA, *Nicholson*, Mon. Brit. Strom., pt. 1, pp. 80, 88, 89, pl. 8, figs. 1-8, 1886
BEATRICEA NODULOSA, *James*, Jour. Cin. Soc. Nat. Hist., vol. xv, p. 95, 1892
BEATRICEA NODULOSA, *Harper and Bassler*, Cat. Foss. Trenton and Cin. Periods in the Vicinity of Cincinnati, p. 2, 1898
BEATRICEA NODULOSA, *Whiteaves*, Can. Rec. Sci., vol. vii, p. 133, 1897
BEATRICEA NODULOSA, *Cummings*, 32nd Rep. Dept. Geol. and Nat. Res., Indiana, p. 700, pl. 1, figs. 1a and 1b, 1908
BEATRICEA NODULOSA, *Foerste*, Bull. Den. Univ., p. 300, November, 1909
BEATRICEA NODULOSA, *Knott*, Geol. of Marion Co., Ky., p. 32
BEATRICEA NODULOSA, *Auctores* See references description of genus by Nicholson and Billings *op. cit.* Numerous references without description.

On account of the extended description of the genus which has been reproduced in full from Nicholson's Monograph it is unnecessary to add anything to Billings' original description, which follows:

"The surface of this species is covered with oblong, oval, or sub-triangular projections from one to three lines in height each terminating in a rounded blunt point which is nearer to one

end of the prominence than to the other. Some of the projections are six or seven lines in length at the base, and twice as wide. Generally they are smaller and often with a nearly circular base; the distance between them is from one to three lines. They exhibit in some specimens a tendency to an arrangement in rows following the length of the stem. In some cases these rows wind around the stem in spirals. In addition to these characters the whole surface is fretted with minute points, and these when partially worn show a perforation in their centres.

"In a specimen three inches in diameter, the diameter of the central tube is three-quarters of an inch; the transverse septa are thin, very concave, and at a distance from each other varying from one line to one inch."

Given an individual example of this species and one of *B. undulata*, it would not be difficult to write an account of the microscopic difference between the two species, but when one examines a number of sections these differences are seen to disappear. My collection is not very extensive, but it seems to bear out Nicholson's conclusions as to the impossibility of separating the species by microscopic examination.

Professor Hyatt states that *B. nodulosa* is a much smaller species than the other, not reaching a length of over four feet and a diameter of from three to five inches at the larger end.

The minute structure of the species has been so fully described in the quotation from Nicholson descriptive of the genus that nothing need be added here. Figures 2, 3, 4 and 5 are reproduced from his monograph. Figure 8, exhibiting the general character of the surface, is a one-half size photograph from specimen No. 1162 of the American Museum of Natural History. Figure 7 represents a remarkable specimen showing the characters of *B. undulata* above and those of *B. nodulosa* below. (Am. Mus. Nat. Hist., No. 1164.)

Locality.—Anticosti (Hudson River), Wreck Point, Salmon River, Battery Cliff, Macastey Bay, English Head, and Gamache Bay, Anticosti; Hudson River, Stony Mountain, Manitoba; Saluda formation of Indiana, Cincinnatian of Ohio and probably of Kentucky and Tennessee.

BEATRICEA NODULIFERA, *Foerste*.—Plate XXV, Fig 10

BEATRICEA NODULIFERA, *Foerste*. Bull of the Denison University, p 297, pl vii, fig 13, pl viii, fig 5, Nov 1909

Cylindrical stems with nodes more or less irregular in arrangement, but tending toward arrangement in vertical rows is most pronounced, some of the nodes are connected sufficiently to suggest vertical ridges separated by more or less irregular furrows. The lateral distance between these rows or ridges varies from 5 to 7 millimetres. In other specimens, the arrangement is more irregular. Specimens 50 millimetres in diameter have been collected, and the species is known to attain a larger size. The stems were several feet in length and grew in a vertical position, tapering slowly toward the top

"*Geological position.* The type specimens were obtained five feet below the base of the Devonian limestone, at a small falls a quarter of a mile south of the Sulphur Spring, three miles southeast of Lebanon, Kentucky. Here *Columnaria* and *Tetradium* occur within three feet of the base of the Devonian limestone, and *Beatricea nodulifera*, *Beatricea undulata*, *Heterospongia subramosa*, and *Columnaria* occur two feet lower. This horizon is regarded as the base of the Liberty bed. Specimens have been found at the same horizon at Bardstown, Kentucky"

BEATRICEA NODULIFERA INTERMEDIA, *Foerste* —
Plate XXV, Fig 9

BEATRICEA NODULIFERA INTERMEDIA, *Foerste*. Bull. of the Denison University, p 300, pl viii, figs 4a, b, and c, Nov. 1909

"Among the various aberrant forms of *Beatricea* found in Kentucky is one in which the nodes are considerably elongated forming short ridges. The upper end of one of these short ridges frequently terminates slightly to the right or left of the lower end of one of the short ridges located farther up the stem, thus resulting in a vertical serial arrangement similar to that of *Beatricea nodulifera*. It is probably one of the extreme variants of that species.

"*Geological position.* Near the base of the southern extension of the Liberty bed, in Marion county, Kentucky."

APPENDIX

Certain forms have been referred to in the literature or on old labels concerning which I have been unable to procure any information; generic have been included in the Stromatoporoids which very doubtfully belong there, and other forms have been removed from the association on the evidence of their microscopic structure. Brief explanatory notes concerning these forms will be found below.

Stromatocerium pustulosum, Safford. Regarding this species Miller says "not defined." Specimens bearing this label are of such poor preservation that sections are unsatisfactory. It is probably identical with *Stromatocerium huronense* or its variety *australe*.

Stromatopora hindei, Nicholson. James states that a specimen resembling this form occurs at Cincinnati. As the species has been removed from the Stromatoporoids, it requires no further comment. (See Niagara Stromatoporoids, p. 56.)

Stromatopora indianensis, J. F. James. The specimen on which this species is founded is said by James to be in the United States National Museum. Dr. Bassler is unable to locate the type and, as the description is entirely inadequate, it must be abandoned for the present. (Jour. Cin. Soc. Nat. Hist. vol. xv, p. 92.)

Stromatopora lyoni, James, and *Stromatopora cincinnatiensis*, James. These species are listed by Mickleborough and Wetherby in Vol. I of the Journal of the Cincinnati Society of Natural History as occurring near Cincinnati. I have been unable to find any other reference to them, either in earlier or later literature.

Stromatopora lichenoides, James. Described by U. P. James in the third number of the Palaeontologist, 1879. Dr. Bassler has proved this form to be the basal expansion of a species of *Arthropora* (Proc. U.S.N.M., vol. xxx, p. 56, 1906.)

Stromatopora ludlowensis, James. Described in Vol. VII of the Journal of the Cincinnati Society, 1884. Identical with

Ceramoporella distincta, Ulrich (Bassler, Proc. U.S.N.M., vol. xxx, p. 57, 1906.)

Stromatopora tubularis, James. Described in Vol. VII of the Journal of the Cincinnati Society, 1884. Identical with *Ceramoporella distincta*, Ulrich. (Bassler, Proc. U.S.N.M., vol. xxx, p. 57, 1906.)

Clathrodictyon variolare, Rosen. This is essentially an Upper Silurian form. I know of no other occurrence of the genus in the Ordovician. For description see "Niagara Stromatoporoids," p. 19. Dr Whiteaves states (Can. Rec. Sci., vol. vii, p. 130): "Specimens which appear to be referable to this species were collected from the Hudson River formation at the Jumpers, Anticosti, by J. Richardson in 1856, and at Cape Smyth, Lake Huron, by R. Bell, in 1859."

Actinostroma trentonense, Weller, Pal. New Jersey, vol. [illegible], p. 139. Probably identical with *Stromatopora* (*Syringostroma*) *compacta*, Billings. Not a Stromatoporoid.

Stromatocerium richmondense, Miller, Cin. Soc. Nat. Hist., vol. v, p. 41, 1882. Removed to *Stromatocerium* (*Stromatocerium*) by Ulrich. A calcareous sponge of which several have been described from the Trenton and Hudson River formations.

EXPLANATION OF PLATES XXI TO XXV.

(All figures not otherwise specified are enlarged ten times.)

PLATE XXI

Fig. 1.—*Stromatocerium michiganense.* Vertical section. Drift of Ann Arbor, Michigan, U.S.N.M., no. 56843.

Fig. 2— " " Tangential section. As above.

Fig. 3—*Stromatocerium rugosum.* Vertical section. Lake Champlain, New York State Museum.

Fig. 4— " " Vertical section. Kirkfield, Ont.

Fig. 5— " " Tangential section. Pauquette's Rapids, Ont. (Granular layer not preserved.)

Fig. 6— " " Tangential section. Pauquette's Rapids, Ont. (Granular layer preserved.)

Fig. 7— " " Weathered vertical surface of the natural size. Pauquette's Rapids, Ont.

Fig. 8—*Stromatocerium canadense.* Vertical section. Pauquette's Rapids, Ont.

Fig. 9— " " Vertical section. Gloucester, Carleton Co., Ont. (U.S.N.M., no. 49502.)

PLATE XXII.

Fig. 1—*Stromatocerium canadense.* Vertical section. Gloucester, Carleton Co., Ont. (From a specimen presented by Mr. W. R. Billings.)

Fig. 2— " " Tangential section. As above.

Fig. 3—*Stromatocerium canadense minimum.* Vertical section. Frankfort, Ky. (U.S.N.M., no. 36930.)

Fig. 4—*Stromatocerium huronense.* Upper surface, natural size. Cape Smyth, Lake Huron. (Geol. Sur. of Canada.)

Fig. 5— " " Upper surface, magnified 1.7 times. Wilmington, Ohio.

Fig. 6— " " Vertical section. Clarksville, Ohio. From the type of *Alveolites granulosus*, James. (Walker Mus., Univ. of Chicago, no. 2250.)

Fig. 7— " " Vertical section. Cape Smyth, Ont. (British Museum specimen.)

Fig. 8— " " Vertical Section. Wilmington, Ohio.

Fig. 9— " " Tangential section, Wilmington, Ohio.

Fig. 10— " " Tangential section, Clarksville, Ohio. (Type of *Alveolites granulosus.*)

Fig. 11—*Stromatocerium huronense australe.* Vertical section. Nashville, Tenn. (U.S.N.M., no. 49507.)

Fig. 12—*Labechia macrostyla.* Vertical section. Drift of Ann Arbor, Mich. (U.S.N.M., no. 36929.)

PLATE XXIII.

Fig. 1—*Labechia macrostyla.* Tangential section. Drift of Ann Arbor, Mich. (U.S.N.M., no. 36929.)
Fig. 2— " " Tangential surface. Natural size. As above
Fig. 3—*Labechia subcylindrica.* Surface. Natural size. Near Morrow, Warren Co., Ohio. Type. (Walker Museum, Univ. of Chicago, no. 1199.)
Fig. 4— " " Vertical section. As above.
Fig. 5—*Stromatocerium huronense.* Vertical surface. Natural size. Wilmington, Ohio.
Fig. 6—*Labechia subcylindrica.* Surface magnified 1.7 times. From type as above
Fig. 7— " " Tangential section. As above
Fig. 8—*Dermatostroma papillatum.* Surface. Natural size. Cincinnati, Ohio. From type. (Walker Museum, Univ. of Chicago, no. 160.)
Fig. 9— " " Surface magnified 1.7 times. As above.
Fig. 10— " " Tangential section. As above.
Fig. 11—*Labechia macrostyla.* Tangential section. From polished surface. Drift of Ann Arbor. (U.S.N.M., no 36929.)
Fig. 12—*Dermatostroma papillatum diversum.* Surface. Natural size. Cincinnati, Ohio. (U.S.N.M., no 56844.)

PLATE XXIV

Fig. 1—*Dermatostroma scabrum.* Surface. Nat. size. Warren Co., Ohio. (U.S.N.M., no. 40080.)
Fig. 2— " " Vertical section. Blanchester, Ohio (Walker Mus., Univ. of Chicago, no 1555.)
Fig. 3— " " Surface. Magnified by 1.7. Warren Co., Ohio. (U.S.N.M., no. 40080.)
Fig. 4—*Dermatostroma glyptum.* Surface. Nat. size. Wilmington, Ohio. (Univ. Tor. Mus. no. 816 H.R.)
Fig. 5— " " Surface. Magnified by 1.7. As above
Fig. 6— " " Tangential section. As above
Fig. 7—*Dermatostroma corrugatum.* Surface. Nat. size. Wilmington, Ohio (Univ. Tor. Mus., no. 817 H.R.)
Fig. 8—*Dermatostroma canaliculatum.* Surface. Nat. size. Waynesville, Ohio. (U.S.N.M., no. 40082.)
Fig. 9— " " Surface. Magnified by 1.7. As above.
Fig. 10—*Dermatostroma corrugatum.* Tangential section. As above.
Fig. 11— " " Vertical section. As above.
Fig. 12—*Dermatostroma cavernosum.* Surface. Nat. size. Mount Pleasant, Tenn. (U.S.N.M., no 49508.)
Fig. 13— " " Vertical section. As above.
Fig. 14—*Dermatostroma corrugatum.* Surface. Magnified by 1.7. As above.

PLATE XXV.

Fig. 1—*Beatricea undulata.* Surface. Nat. size. Anticosti. (Hamilton Scientific Association.)

Fig. 2—*Beatricea nodulata.* Transverse section x 1.6. After Nicholson.

Fig. 3— " " Vertical section x 1.5. After Nicholson.

Fig. 4— " " Transverse section x 12. After Nicholson.

Fig. 5— " " Transverse section x 24. After Nicholson

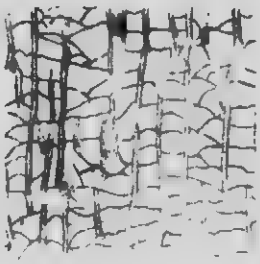
Fig. 6—*Beatricea undulata.* Surface x ½. Marion Co., Ky. (Am. Mus Nat. Hist., no. 1163.)

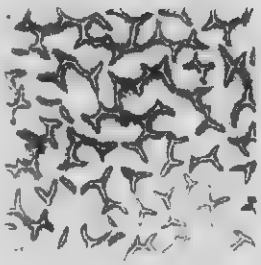
Fig. 7—*Beatricea undulata* vel *nodulosa.* Surface x ½. Marion Co., Ky. (Am. Mus. Nat. Hist., no. 1164.)

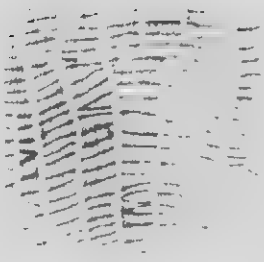
Fig. 8—*Beatricea nodulosa.* Surface x ½. Marion Co., Ky. (Am. Mus. Nat. Hist., no 1162.)

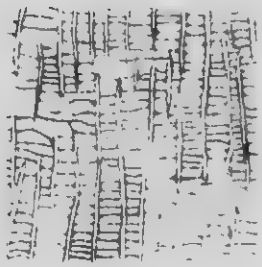
Fig. 9—*Beatricea nodulifera intermedia.* Surface x 0.8, Lebanon, Ky., After Foerste.

Fig. 10—*Beatricea nodulifera* Surface x 0.8. Lebanon, Ky. After Foerste.









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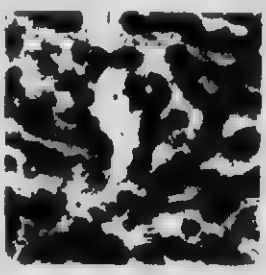

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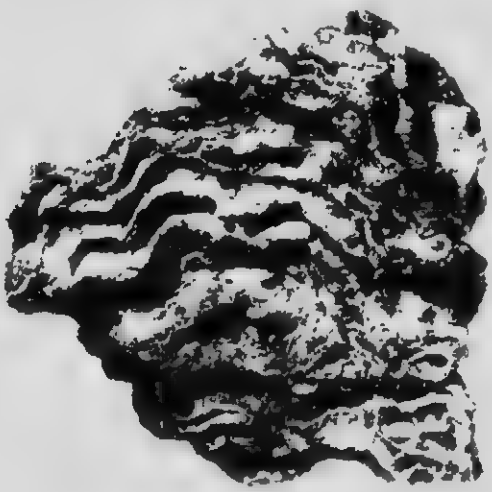

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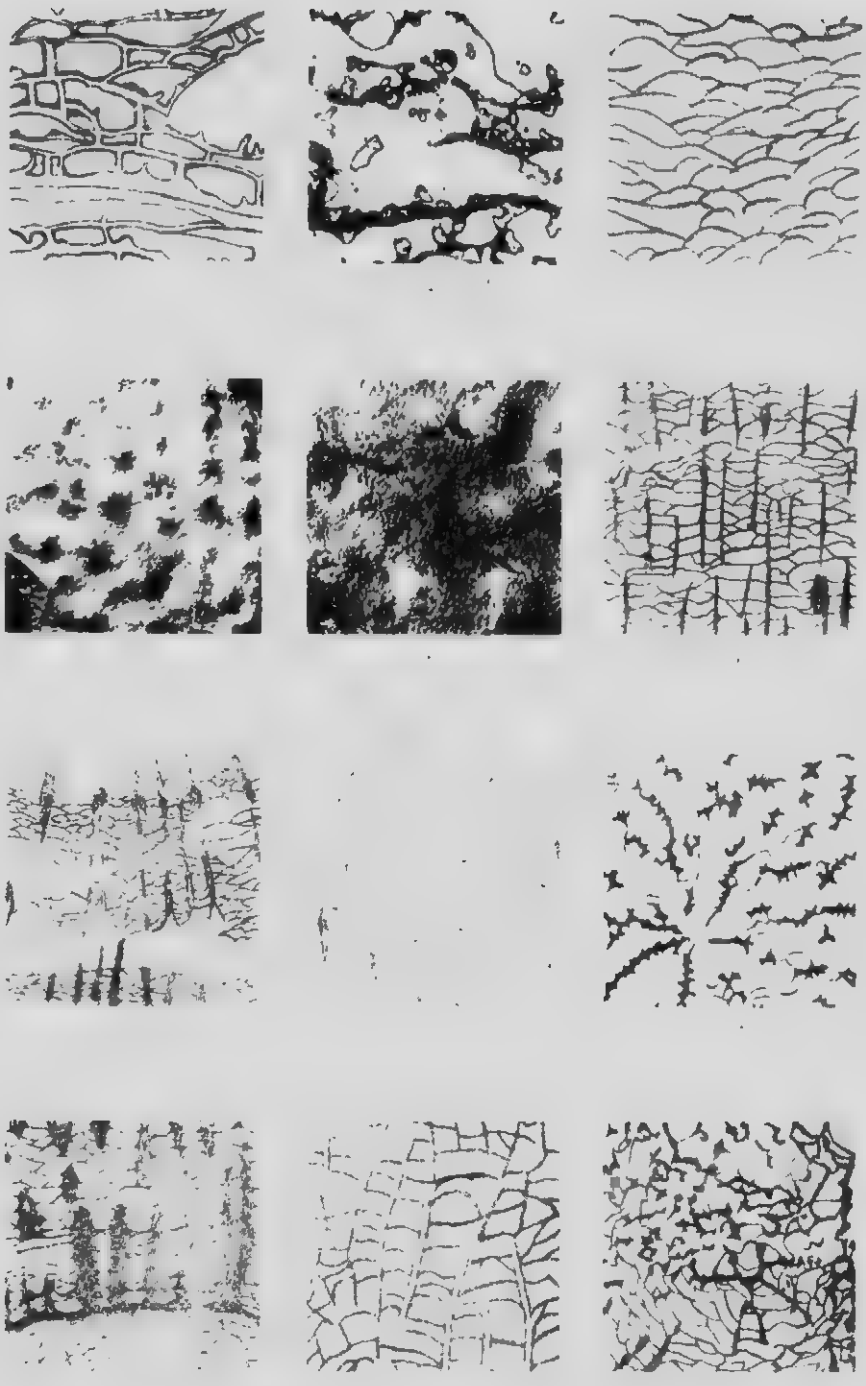

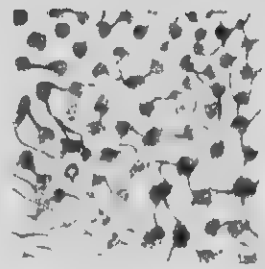
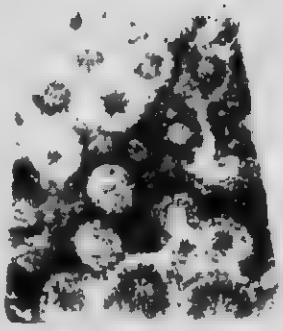

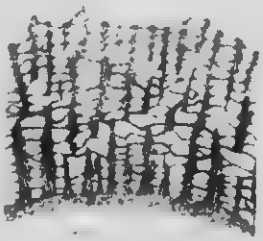
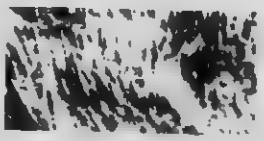

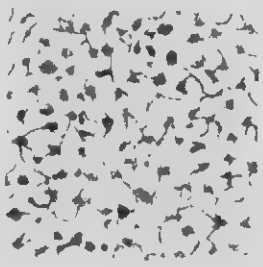
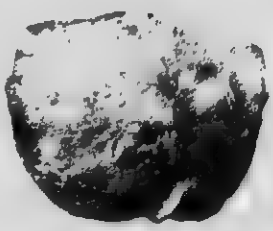


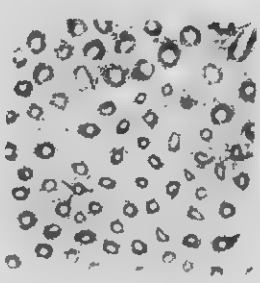


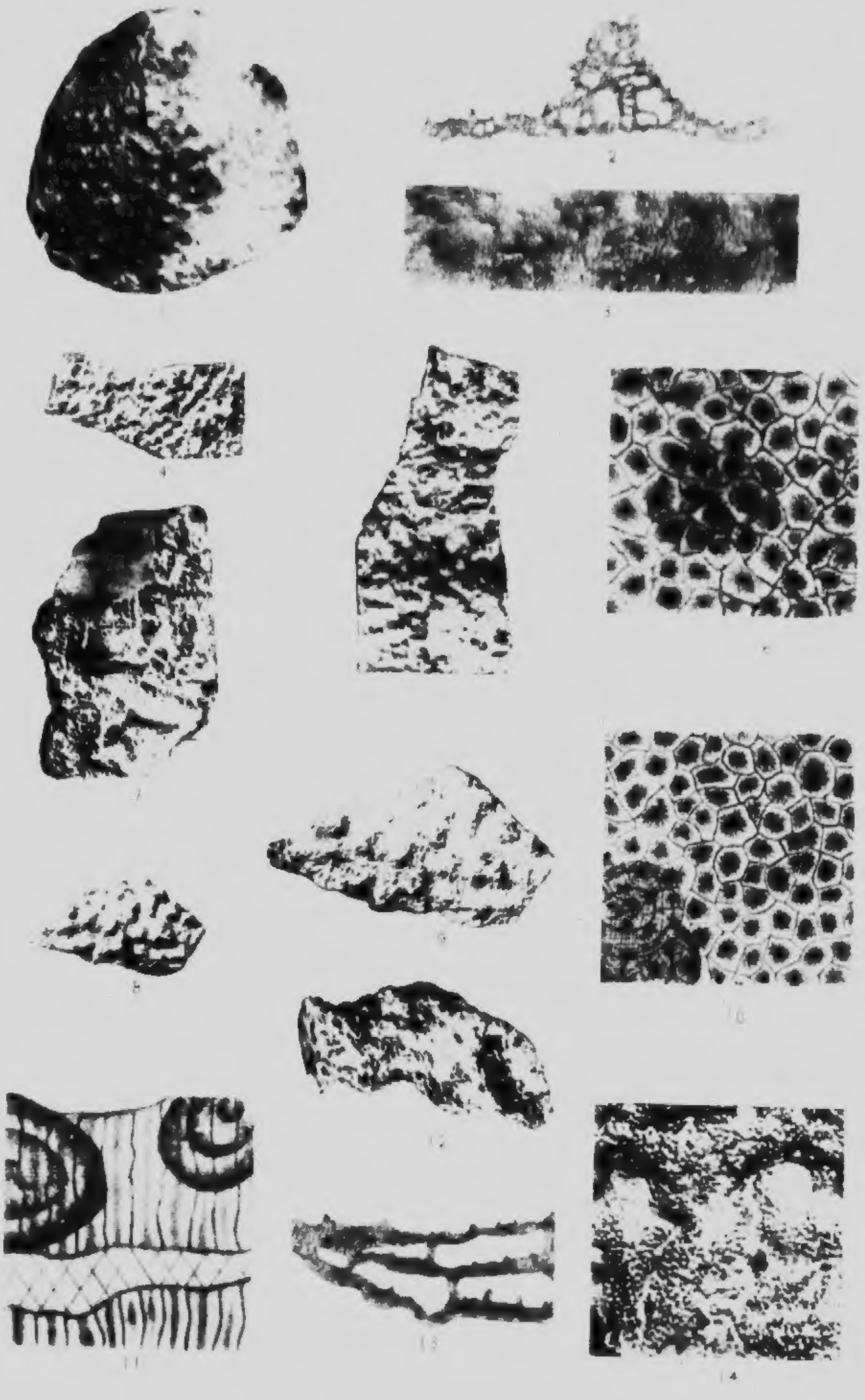
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